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FRONTISPIECE.

ENLARGED FROM F. P. KODAK $2\frac{1}{4}'' \times 1\frac{3}{4}''$.

To illustrate advantages of a small camera for such subjects as that shown.

PLATE VI

AGRICULTURAL MUTUAL CREDIT IN FRANCE AND THE WAR.

ERRATA.

(i) Vol. XI, Part I, of this Journal.

In the article on "Indian Hemp Fibre," pp. 31—41, substitute "Sann-hemp" *for* "Indian hemp" wherever it occurs.

(ii) Special Indian Science Congress Number of the Journal.

Page 96, 4th line from bottom. For "to evaluate time" *read* "time to evaluate."

of the public at the beginning of hostilities

"These societies found themselves in the same position as the Savings Banks and other institutions of credit that were in direct contact with the savings of the people, and like these they were liable to see their clients insist upon their deposits being refunded.

"Their situation, however, has been quite different: no demands have been made for repayment: there was no need for a moratorium. They have even received, since the beginning of the war, new deposits of the total value of 120,000 francs.

"In the country districts, the people are only too much inclined to believe that debts need not be paid during the war, and one might be inclined to predict that the repayment of small debts would be

suspended, the moratorium having, moreover, deferred the time of their falling due to an undetermined date.

" The agricultural credit institutions of Burgundy and Franche-Comté have upset the least pessimistic forecasts of this kind and proved themselves capable of facing the most critical situations. In fact, the Regional Bank, seeing that the cultivators were realising large sums on account of the requisitions and the rise in the prices of the products of the soil and of cattle, insisted on the local banks obtaining at least partial, if not complete, repayment, whenever the condition of the borrowers permitted it, without in any way involving in difficulties the families of the men mobilised. Since the beginning of the war the sum of 434,000 francs has been received under the head of repaid loans.

" With the deposits entrusted to it, and the repaid loans *plus* the sum standing to its credit with its banker at the beginning of the year and which the banker paid into it, the Regional Bank has bought over 900,000 francs worth of Treasury bonds."

THE HAND-FEEDING AND MANAGEMENT OF BUFFALO CALVES AT A DAIRY.

BY

ROBERT G. ALLAN, M.A.,

Principal, Agricultural College, Nagpur;

AND

J. V. TAKLE, L.Ag., N.D.D.,

College Dairy Overseer, Nagpur.

Calf raising, though frequently neglected or carelessly carried out, is an important section of dairy management. The importance of the subject is proportional to the milk capacity of the individual buffaloes and cows forming the herd; to the difficulty of procuring, by purchase, substitutes in their place and to the money value which is likely to be got for such animals as it is necessary to sell from the herd. Dairying on modern lines, with due care to hygienic conditions and purity, cannot be worked at a profit by filling up a herd with inferior low-yielding animals and by depending on the number of animals rather than on the quality of the individual for the necessary bulk of milk. When the animals of a dairy herd are individually poor there is little scope for or inducement to the careful raising of the progeny. On the other hand, good milkers are comparatively rare and the present system in many dairies of making no real attempt to raise the calves properly and of depending on the purchase of milk stock from external sources is creating a drain on the supply of good milkers (for example the Sindhi breed of Karachi and the Murrah buffalo of Delhi) and raising the price without any adequate effort to repair or replace the loss to which the milk interests of the future are being subjected.

Given that a foundation herd of carefully selected good milkers is established, due attention to the raising of the progeny, in particular the progeny destined to extend the herd or replace its older members, is both desirable and profitable. A herd which is dependent on purchases for extension and replacement can never really hope to make that definite improvement in individual milk production which is the foundation of profitable dairying. At the same time the chances of the introduction of disease into the herd are much greater in one based on purchase than in one based on home breeding and raising. If it is intended that the future stock be raised in the dairy, the raising must be carefully done. Otherwise the death-rate among the calves will be high and such as come to maturity will fail to maintain the milk producing level of their dams. In the writers' opinion a very fair proportion of the blame for the low yield of Indian buffaloes and cows is to be attributed to the wretched conditions of food and care under which they are raised during the first 7-8 months of their lives, as young calves. It is commonly remarked that she-buffaloes raised in big dairies have seldom, if ever, the milk production of purchased buffaloes from up-country. This is entirely due to the lack of care and sufficient food generally given to calves at such centres. In the writers' opinion and experience, home-raised Delhi buffaloes will give an equal or even better production than their dams, provided a certain amount of care is given in the earlier months of their existence. They can be raised as satisfactorily, if not more so, on a diet of separated milk and a proper substitute, as when allowed to suckle freely. Indeed in certain cases, calf ailments are traceable to the high fat percentage and excessive richness of the dam's milk.

The notes on calf raising which follow are the result of the practice found most satisfactory at the College Experimental Dairy. The system of calf raising outlined here is based on the possession of a herd of medium to good milkers and is restricted to such of their progeny, essentially the female side, which it is intended shall be used for the replacement or the extension of the existing herd or to such as will find a market at a reasonable figure if sold off.

The larger majority of the calves handled by the dairy are buffalo. The buffalo calf is an easier animal to separate from its mother and to hand-feed and the mother is less influenced by the presence or absence of her calf. They are, however, much more delicate than cow calves, and unless care is taken, the mortality may be as high as 75 per cent. Cow calves separated from their mothers can be raised by hand with a little patience though they take to pail-feeding more slowly. Usually, unless the first calf is separated, the maternal instinct of the mother is so strong as to render complete separation of a later calf almost impossible and any attempt to do so produces an adverse effect on the dam's production. Many of the points recorded here are common to both buffalo and cow calves and the methods recommended for raising buffalo calves are equally applicable to cow calves. Since the introduction of these methods in the college herd there has been no mortality among buffalo calves and only one calf died during the period of about twenty months.

For experimental purposes at the dairy and in order to test principles, all calves are maintained alike, though the male buffalo calf receives a slightly lower diet. The male buffalo calf is however an animal which it is scarcely worth raising on any improved lines unless destined as a possible herd sire. Economically, they are more profitable if dead than when alive, and an enquiry into any Indian *gaolee's* business will show that the death-rate among buffalo males is out of all proportion to natural causes and that their natural delicacy, as they are harder to raise than females, is made the most of.

The Dairy deals in both whole milk and milk products. A fair proportion of the buffalo milk is separated. This separated milk provides the basis of the young stock feeding, the balance being sold off.

The high death-rate among young calves, in particular buffalo calves, arises from one or oftener a combination of the following causes :

(1) Lack of sufficiency, regularity and frequency of feeding.

(2) Lack of cleanliness.

(3) Lack of sufficient exercise.

(4) Absence of care at the time of birth and absence of preventive steps against scour, white scour, worms and bronchial diseases.

After a few remarks on the condition preceding birth the subject of calf raising by hand will be dealt with from these standpoints.

WHILE IN CALF.

In the large majority of cases the average buffalo remains dry for from 2-4 months. In only two cases in the writers' experience has this period been less than one month. The length of time for which the buffalo will remain dry is dependent on the breed, on the individual, on the length of time which elapses between calving and covering, and on the quality of the fodder supply. The general average amongst the breeds on the college farm is for Delhis 10½ months in milk, 2 months dry ; Surtis about 12 months in milk and 3½-4 months dry ; Local (Deccani) about 9-10 months in milk and 4-4½ months dry. Thus the necessity of forcibly drying off so as to permit of 6 weeks' rest is so rare as scarcely to require attention. During the earlier part of this period a good supply of nutritious fodder is all that is essential. If the fodder is of poor quality, as is sometimes the case in the hot weather, a small amount of some cheap concentrated food, for instance undecorticated cotton cake, can be fed. It is a mistaken policy to underfeed a milker during the rest period, more especially if she is a high yielder and if the time of rest between drying off and calving is likely to be short. Rich food is not necessary—only an ample amount of digestible material in the fodder is required. Such concentrated food as may be fed in this period is only to be regarded as making good any defects in this respect in the fodder which the owner is forced to feed. Some 3-5 weeks before calving is due, there should be a small addition given in the form of concentrated. This amount should be increased weekly up to calving time, so that she calves on a rising state of vigour. The length of this period of concentrated food and the amount finally fed in the week previous to parturition are dependent on the length of time the animal has been dry or without direct concentrated food and the probable milk yield of the buffalo

after she has calved. If the animal has been dry for some months this period should begin sooner. If the milk yield expected is high the increments added each week and the mass total in the last week should be greater. The foods available at economic rates in the country are variable and so no very definite recipes can be given. The following, however, will illustrate this principle and be the first step towards a liberal milk supply and a satisfactory calf. First week, give $1\frac{1}{2}$ lb., second week 2 lb., and then one additional pound per week up to the fifth week when the diet will be 5 lb. The concentrated should consist of a mixture of oil-cake with either bran or *chuni* in about equal parts. The period before parturition is an important one—perhaps of more importance from the stand-point of the female's milk yield than from the quality and vigour of the calf, unless the female is particularly badly treated at this period, which unfortunately is too often the case. Generally speaking, the better the feeding of the female, especially if in first calf, without extravagance, the better the chance of a virile calf and a good milk flow; that is, provided the female inherently possesses a good milking tendency.

During and After Calving.

At first sight the care and feeding of the female at this period would appear to have but little direct effect on the calf, specially one which is to be hand-fed. There are, however, one or two points which must be closely attended to or the result to the calf may be fatal. Before parturition is due, say some 3-4 days, the female should be separated from the herd, removed from the common stalls and placed in a calving stall, preferably a loose box. In the writers' opinion a room of galvanized iron, with a removable thatch above the iron roof and having a stone floor, and fitted with a half door for ventilation, is suitable. Such a building is sufficiently cool, is easily cleaned, and can be thoroughly disinfected and is free from ticks. The calving female is made comfortable with litter, which should be removed daily or at any rate cleaned and sunned. During this period the diet should be changed to one of laxative type, foods like cotton seed cake and even to some extent *chuni*,

should be avoided. Probably one of the best diets at this period and for some days after calving is one consisting of half *bajra* and half bran or three parts of the former and four parts of the latter. Oats could no doubt replace *bajra ;* but the former is the diet fed by the writers. The amount of this mixture will vary between 4-8 lb. according to the expected milk capacity of the mother. The important points at this stage are a clean spot for calving and a laxative diet to prevent any disturbance in the milk (colostrum) production after calving. One of the commonest sources of loss of calves is navel-ill. This is closely associated with infection from a dirty floor and lack of immediate steps to disinfect and tie up the navel string immediately after separation. A calf dropped in the open rarely suffers from this, and, if a suitable calving shed is not available, probably the next best place to tie up is in the open under shade.

The Feeding and Management of the Calf Immediately After Birth.

The calf should be placed before the mother who will lick it and thus remove most of the mucilaginous matter adhering to it. The calf's mouth and nostrils should be freed of mucilage to permit normal respiration and steps should be taken, as mentioned above, to wash the navel with a 5 per cent. antiseptic lotion and tie it up, using silk thread or gut. If not properly cleaned by its mother the calf may be rubbed down with straw. In some cases the calf may be removed immediately after calving and cleaned down in a separate shed, but there is no direct advantage gained. In about 6-8 hours the female will pass her after-birth and by then the calf will be beginning to attempt to reach the teats. This is a point at which management varies. Some raisers permit the calf to suckle for one or two days, others a week or even longer and others remove the calf entirely. In deciding action certain considerations must be borne in mind. These are (1) the effect of removal on the milk flow of the female, and (2) the effect of non-removal on the aptitude with which the calf will take to hand-feeding later. A certain proportion of she-buffaloes do not appear to be affected by the entire absence of the calf. Others, though not requiring the calf to start

the milk flow, are quieter and more easily handled if their calf is beside them. A few cannot be got to milk unless the calf starts the flow. Usually these are buffaloes which have been permitted in the past to suckle their young. In the case of cows the maternal instinct is greater and a cow which has once been suckled by her calf is difficult to handle in its absence and not infrequently refuses to drop her milk, unless the calf starts the flow. As regards the case of hand-feeding later, there is no doubt that the longer the calves are permitted to suckle, the more difficult it becomes to get them to pail-feed. A buffalo calf, separated from its dam, say a week or 10 days after calving, can be got to pail-feed with little trouble and generally without seriously affecting the milk flow of the dam. A cow calf is extremely difficult to train and, indeed, in some cases, impossible, while the cow, even in her first calf, will probably show a falling off in milk. From these facts the writers believe in the immediate separation of calves, particularly in the case of cow calves. Such separation in the case of the latter is possible only if done at the first calf, before the female has had an opportunity of experiencing the effect. In the case of buffalo it is not so absolutely essential, but, with a view to the greater ease with which the calf takes to the pail, it is probably desirable, unless the udder is caked or out of condition. The mother must of course be thoroughly hand-milked in the absence of the calf. Assuming that early separation is decided on, the calf should get its first lesson in pail-feeding some 6-7 hours after calving. This is done by putting the middle and the fourth finger of the right hand in the calf's mouth. When the fingers are introduced the calf begins to suck, and the hand should then be lowered very gently into a shallow vessel containing between one and two pounds of the colostrum drawn from its mother. In the first efforts the calf draws the milk by sucking on the fingers, but in two or three days it will begin to take up milk from the pail, still assisted by the hand, and within a week will drink direct. During the first 10 or 12 days the calf must get its mother's colostrum. Ordinary milk will not do. During this period it should receive its milk at least 4 times a day. The milk fed immediately after the morning and evening milking needs no special attention.

The milk fed at intervening times must be warmed to about 100-101°F. The vessels in which it is fed must be clean and the milk fed fresh. Neglect of any of the above points will probably lead to stomach troubles. After having its milk, it is advisable to wash the calf's nostrils and mouth with water and wipe them dry.

Calf Feeding.

This section refers to feeding till over, at least, 6-7 months of age. The largest mortality in buffalo calves occurs between the age of 10 days and 4 months. The subject of calf feeding by the aid of separated milk and substitutes is one on which a good deal has been written. The schedule below gives the standard lines on which female buffalo calves and males of possible breeding value are raised at the College dairy. It has worked with complete success for the last two or three years. The variation in the character of the substitutes will be discussed later.

Schedule for Pail-fed Calves.

(All buffalo female calves and males of 2 best milkers.)

I. *Period : length* 45 *days*, 0-1½*m.*—(*a*) First 10 days, mother's colostrum 4-5 times a day.

(*b*) Remainder of time whole milk up to about 5 lb. fed in 4 meals.

II. *Period :* 45 *days*, 1½-3*m.*—Whole milk to give way to skim and linseed gruel substitute.

Beginning with 5 lb. whole milk in 3 feeds, skim milk and gruel replace midday meal and later the other two by a process of gradual dilution, till in about 20 days the diet is 5 lb. skim milk. The linseed starts with a few spoonfuls and is eventually raised to about ½ lb. 3 feeds per day. A small quantity of bran and *chuni* is given during this period.

III. *Period :* 45 *days*, 3-4½*m.*—Continue skim feeding 5-6 lb. with (1) ⅔ lb. linseed as gruel followed by 1 to 1¼ lb. bran and *chuni*, or (2) replace linseed and bran-*chuni* by 1 lb. *juar* meal and 1 lb. bran fed after milk. In this period the midday meal should be skim milk with a little linseed gruel or skim milk with a handful of

juar-bran, the bulk of concentrate being fed morning and evening, 3 feeds per day.

IV. *Period:* 45 *days*, $4\frac{1}{2}$-6*m*.—Replace the linseed gruel or a portion of *juar* by cake. Reduce skim milk and cutting out midday meal till in about 10-15 days the milk ceases and the diet is

(1) $\frac{1}{2}$ lb. bran	$\frac{1}{2}$ lb. cake	$\frac{1}{2}$ lb *chuni*
or (2) $\frac{1}{2}$ lb. bran	$\frac{1}{2}$ lb. cake	$\frac{1}{2}$ lb. *juar* meal.

2 feeds per day.

V. *Period:* 45 *days*, 6-$7\frac{1}{2}$*m*.—Increase concentrates.

(1) $\frac{2}{3}$ lb. bran	$\frac{2}{3}$ lb. cake	$\frac{2}{3}$ lb. *chuni*
or (2) $\frac{1}{2}$ lb. bran	$\frac{1}{2}$ lb. cake	1 lb. *juar* meal.

2 feeds per day.

VI. *Period:* 135 days, $7\frac{1}{2}$-12*m*.—Reduce concentrates till by 10 months or so, 1 lb. is being fed of either of above mixtures, 2 feeds passing to one.

Fine fodder should be given in the second period and by its close the calf should be consuming a fairly appreciable amount. It should be allowed access to what it requires. The fodder given should be of good quality. It should also be as succulent as possible. If, however, it is unused to succulent material its introduction should be gradual, though eventually it can form a large part of the fodder diet. At the College farm succulent food is met between mid-July and mid-September by grass, mid-September to mid-December by *sorghums*, from mid-December to mid-April by berseem and the balance of the year by silage. Very young calves, if born in the silage period, depend on a small quantity of guinea grass in the early stages of fodder feeding. The milk or separated milk fed should approximate in temperature to about 100°F. Morning and evening feeds immediately after separation do not require special attention, as, at the dairy, separation of buffalo milk for butter or *ghi* purposes follows immediately on milking and the fall in temperature is inappreciable. The midday feed requires warming to about 100-101°F. The linseed is weighed out according to the needs of the stock and made into a gruel, using 1 part of linseed to 6 of water. A quantity of this gruel proportional

to the weight of linseed due to a calf, is then mixed with the skim milk. An important point is that the vessels in which the milk is fed must be kept thoroughly clean and should be scalded as thoroughly as if for human use. Calf illness is not infrequently traceable to lack of care in this respect. The grain feed is weighed out on the same lines, moistened some time in advance and fed by measure after the milk. At feeding time the calves are tied separately ; each then receives its portion in an iron bowl. Tying at feeding permits the slower eater to complete without being worried or robbed, prevents calves sucking each other and ensures that each gets its proper share. Attention should be given to the dung, generally passed after feeding, as this affords a fairly ready index of health and the suitability of the diet. It is a mistake to imagine because skim milk is being fed in place of whole milk that a larger bulk of milk is necessary for support. The amounts of milk fed in the schedule are sufficient, and attempts to markedly increase these have generally resulted in diarrhœa.

With regard to the nature of the substitute the writers are of the opinion that up to about the middle of the second period linseed gruel forms one of the best substitutes. After that date considerable variation is possible.

The following experimental feeding illustrates this and is the cause of the duplicate feeds in the schedule. Frequently it may be found to be more economical to use a grain diet. The calves of both groups were alike in age and averaged about 3 months, and up to the date of starting the experiment, both had been raised on separated milk and linseed as outlined.

The diets for groups A and B were as follows :—

	Group A	Group B.
1st period 45 days.	5 lb skim milk 2/3 lb. linseed gruel ½ lb. bran, ½ lb. *chuni* } fed after milk	5 lb. skim milk 1 lb *juar* meal, ½ lb. bran } fed after milk
2nd period 45 days.	½ lb. *chuni* ½ lb. bran ½ lb. *tilli* cake	¼ lb. *juar* meal ½ lb. bran ½ lb. *tilli* cake
3rd period 30 days	2/3 lb. *chuni* 2/3 lb. bran 2/3 lb. cake.	½ lb. *juar* meal ¼ lb. bran ½ lb. cake.

Thus in group A in the first period there was higher proportion of oil and proteid, in group B a higher proportion of carbohydrate. In the subsequent periods A differed from B in having a higher proportion of proteid. All the animals maintained a good condition and the development of the parts of the body was alike. In the first period, animals in B group in the beginning showed some slight tendency to scour and they were at the end perhaps a little softer on handling.

The following are the progressive average gains per head of each group :

	End of 30 days	End of 60 days	End of 90 days	End of 120 days
Group A	18 lb.	38 lb.	68 lb.	92·6 lb.
Group B	31 lb.	59·6 lb.	91 lb.	119 lb.

Group B thus made an average gain per head of 26·4 lb. in 4 months.

The amount fed	A per head	B per head
Skim milk	195 lb.	195 lb.
Linseed	25 lb.	—
Juar-meal	—	93 lb.
Chuni	95 lb.	—
Bran	48 lb.	60 lb.
Cake	49 lb.	49 lb.
Cost Rs.	13-10	12-10
Price per lb. of increase live weight. ...	2·35 annas	1·70 annas.

Feed B thus gave a greater increase and cost 0·65 anna less per lb. As there are considerable divergences in the characters of the two diets a fairly wide margin of food stuffs is apparently possible. The general results bear out similar experiments on cow calves in America.

Housing and Exercise.

Young calves do not require very elaborate housing, at any rate in the Central Provinces. The general calf shed is a galvanized iron building covered with a thatch, protected towards the south-west and north and open towards the east. In the writers' opinion

both the iron and the thatch are important. Iron prevents the existence of harbours for ticks and other parasites and an external thatch makes such a building habitable in the hot weather. The floor of the shed is dry earth and raised about 6″-7″ above the general ground level. It is divided into three compartments and each compartment has a fenced run to the east of the shed, about four times the width of the shed in length. Possibly four sections might be advisable, but are not essential.

In the coldest and wettest parts of the year, the youngest calves are generally housed at night in a large loose box, as, if unprotected, they are subject to broncho pneumonia. In the general shed the chief points to pay attention to are (1) protection against rain and excessive heat, (2) freedom of movement at will, (3) a grading of the calves to each section according to age and size, and (4) cleanliness. In addition to the movement possible in the small paddock, calves should be allowed to go out daily in a neighbouring field in the general farmyard. Ample, though not excessive, exercise is an important item in keeping them fit.

Watering, Salt and Lime.

During the first month or so the calf shows no demand for water—the water in the milk being sufficient; after this—in particular when they have begun to take up fodder—the need increases. There should be ready access to a clean water supply, preferably in a water trough in the calf pens. If this is not fitted in the calf pens, they should be taken to the water supply at least twice a day in the cold weather and four times a day in the hot. The fact that a calf needs water in addition to what it gets as milk is too often overlooked in rearing calves by hand and causes the calf to gorge the milk with bad effects.

Salt is an essential. It should be supplied in small quantity with the concentrated food. At the same time it is not a bad plan to have a block of rock salt hung in each pen or shed. It

strengthens the appetite and stimulates digestion, a factor of some importance in keeping condition. In the pen in which the calves under three months are kept it is advisable, in addition to rock salt, to hang up one or two blocks of chalk. The young calves will lick these readily. The effect is two-fold—prevention of scour and a prevention of the habit of licking the floors and ground, which is not infrequently the cause of stomach trouble and intestinal worms. The necessity for lime appears to decrease as soon as the diet begins to include an appreciable amount of dry food.

Other Points of Care.

Buffalo calves, generally, are exposed to attacks of hoose, broncho pneumonia, scour, white scour, tympany, intestinal worms, mange and lice. If care is taken on the lines indicated in this article, the possibility of these is very largely reduced. In addition, however, two points might be mentioned which have been found of considerable value in checking mortality. The first is an inspection of the dung and prompt action if anything abnormal is noticed. The second is the administration of preventive doses, at intervals, of raw linseed oil and turpentine.

The following is the schedule of this measure as adopted at the dairy.

Age	Quantity of linseed oil	Quantity of turpentine	
1st month	1 oz.	$\frac{1}{8}$ oz.	To be administered once every fortnight.
2nd, 3rd and 4th months.	$1\frac{1}{2}$—2oz.	$\frac{1}{4}$ oz.	
5th and 6th months ...	2 —$2\frac{1}{2}$oz	$\frac{1}{2}$ oz.	
7th-12th „ ...	3 oz.	1 oz.	Administered once a month.

The usual methods of dealing with ringworm, mange and lice need no repetition.

Calves over one year—development of the buffalo heifer. Practically speaking from about 10 months old and onwards calves require but little special attention as long as they receive

ample digestible fodder, free access to water and exercise. Though inferior or inadequate nourishment should be carefully avoided, the effect of a temporary falling off of this at this time is not so disastrous as in the early stages. Concentrated foods are not essential except under inferior-quality-of-fodder conditions. A certain amount of grain during this period will result in a bigger growth and earlier maturity. A regular grain ration at this period is however too expensive to be economical. Grazing is the cheapest and, if ample, is the best way of raising the calves. At the College dairy, on account of the absence of grazing of any real value, the young stock are raised on fodder. The only advantage of feeding on fodder lies in the fact that the quantity and quality are more regular throughout the year. Most Indian grazing is defective in these respects. If young stock are to be raised on such grass areas it is necessary to reserve some of the area for hay. Cut and store this in October and feed a liberal hay ration between February and the end of July. During this period about a couple of pounds of concentrated is desirable, in order to keep the animals in a thrifty growing condition. The amount of this concentrated will naturally depend on the quality of the roughage. In addition to the hay of the poor local grasses round Nagpur, 2 lb. of cotton seed or 3 lb. of undecorticated cotton cake are found to just maintain heifers in a growing condition at this period. At the College farm, by reason of the inclusion of berseem up to the beginning of April and the better quality of the fodder, concentrates are fed only for about three months, only a pound usually being given. Succulence in the fodder fed has a marked effect in the rate of development. In one case in which the same concentrated diets were used (1) with the dry poor hay available in the hot weather and (2) later with grass in the months of August and September, the average increase in live weight per head over the same time was practically double in the second period. The use of silage as part of the roughage fed in the hot weather can be recommended. A buffalo heifer which has received treatment along these lines will probably be found to weigh about 900—1,000 lb. when 3½ years old before giving birth to her first calf.

Cost of System per head.

		Rs.	A.	P.
1st year	165 lb. of whole milk at 12 lb. per rupee	13	12	0
	350 lb. of separated milk at 30 lb. per rupee	11	10	0
	60 lb. of linseed at 15 lb. per rupee	4	0	0
	187 lb. of *tilli* cake at 40 lb. per rupee	4	11	0
	157 lb. of bran and *chuni* at 22 lb. per rupee	7	2	0
	2,430 lb. of fodder at 200 lb. per rupee	12	2	0
	Labour per calf (estimating 20)	3	3	0
	Shed rental	0	8	0
	Cost for 1st year	57	0	0
2nd year	120 lb. concentrated foods at 40 lb. per rupee ...	3	0	0
	4,440 lb. of fodder at 200 lb. per rupee	22	3	0
	Labour and rental	3	8	0
	Cost for 2nd year	28	11	0
3rd year	180 lb. concentrated foods at 40 lb. per rupee	4	8	0
	5,750 lb. of fodder at 200 lb. per rupee	29	0	0
	Labour and rental	3	0	0
	Cost for 3rd year	36	8	0
	Total cost per head	122	3	0

If the stock in the second and third years are raised on grazing areas where hay would be cheap the cost per head would not exceed Rs. 95. It might even be possible to reduce the cost slightly further by a reduction of the period on whole milk.

A ttheir first calving, any of the young Delhi and Surti buffaloes on the College farm raised on the above lines are worth Rs. 125-130 and more, if we take into consideration the cost of carriage from the place of purchase.

AMERICAN COTTON AND AMERICAN COTTON SALES IN THE PUNJAB.

BY

W. ROBERTS, B. Sc.,

Professor of Agriculture, Agricultural College, Lyallpur.

COTTON sales have become a feature in the successful introduction of American cotton by the Punjab Agricultural Department. It may therefore be of interest to give some account of them. In a previous article[1] in this journal the writer gave a brief account of the history of the introduction of American cotton in the Punjab Colonies. It was then pointed out that the first sale was started in 1905-6, only three years after the first trial of American cotton. From 1908 to 1913 two sales were held annually, *viz.*, one at Sargodha in the Jhelum Colony and one at Lyallpur on the Lower Chenab. In these early sales the object was merely to help zemindars to get a good price for their superior produce. A small quantity of new seed was imported by the Department yearly from Dharwar in the south of Bombay. Comparatively small quantities of cotton (*kapas*) were brought to these sales, a few hundred maunds as a rule. Premiums up to Re. 1-8 and more a maund were obtained but the effect was to fix the price of American cotton for the whole tract. In 1911 and 1912 factory owners began to pay some premiums independently of the sales. In 1913 the Department was in a position to give out a special variety selected by the Economic Botanist and handed over for further trials to the writer. From 1913 onwards these sales acquired a new importance as it

[1] *The Agri. Journal of India*, vol. X, part IV, pp. 343—48.

became necessary for the Department to get back the seed for further distribution. The area sown under this special variety No. 4 F in 1913 was only 100 acres, in 1914 it was 3,000 acres and in 1915 in spite of the effect of the war on cotton sowings the area under 4 F rose to 9,000 acres. In the present season it is estimated that over 30,000 acres will be sown with this variety. In the article previously referred to the writer ventured to prophesy that in spite of the disastrous effect of the war on cotton prices the area under American in the Punjab would not decrease. This was amply fulfilled and something like 65,000 acres was sown with American of all kinds last year. The season, though distinctly bad, was more favourable for American than *desi*. The prices obtained at the sales this year were so good that at a moderate estimate there should be about 120,000 acres sown with American of all kinds in 1916. The above was written during the Meeting of the Board of Agriculture at Pusa (February 1916) and now two months later when cotton sowings have started the whole of the seed with the Department amounting to 2,000 maunds in Lyallpur and Montgomery and about 600 maunds at Sargodha has been already disposed of. Much more could have been sold. Numbers of zemindars, who waited till sowing time before buying seed, have had to be refused daily since April 1st. No better evidence than this is necessary of the willingness of the cultivator to adopt a new thing if it pays him. It is estimated that over 500 maunds seed was retained by last year's growers and hence well over 3,000 maunds of seed has been distributed. The seed rate here is 4 seers per acre and therefore 3,000 maunds means 30,000 acres. The Department now control directly therefore at least ¼th of the area. This year's sales were held at five centres in the Lyallpur circle (as compared to two last year) and two in the Jhelum Colony in the circle of the Deputy Director of Gurdaspur (as compared to one last year). Altogether about 8,000 maunds of *kapas* (seed cotton) was sold at these sales. Of this about 4,500 maunds was first class and was ginned under the Department's supervision for the purpose of getting the seed for distribution. This year some changes were introduced in the conditions of the sales which may have far reaching results. The most important

of these relates to classification of all the cotton by the Department and the leaving of all arbitration in its hands. These conditions were operated with great smoothness throughout and to the satisfaction of sellers and buyers alike.

Another feature of this year's sales was the fact that Messrs. Tata and Sons sent up a representative at the writer's request and it was he who bought the greater part of the cotton either directly or indirectly at the sales.

Very good prices were realized ; in one sale the price paid was Rs. 3-13 more than for *desi* cotton on the same day. The average price per maund of *kapas* in Lyallpur was Rs. 10-12, the price of *desi* being Rs. 7-8. The premium was therefore over Rs. 3. No doubt the war partly accounts for the high price, as imports from America are restricted owing to high freights. Last year, however, when freight was not such a burning question the premium was Rs. 2-13 a maund. In the past season American cotton yielded well per acre as compared to *desi*, though both suffered in yield owing to the excessive drought. The flowers all appear together in the common *desi* cotton grown here and the strain on the plant is enormous at that period. In American, on the other hand, the flowering is much more gradual, and hence the strain at any particular time is less. It was a common sight to see fields of *desi* cotton in July and August strewn with fallen flowers. Zemindars here boldly say American cotton yielded twice as much as *desi*. The extra profit, for 65,000 acres even assuming the American yielded only 1 maund more per acre is over 6½ lakhs without taking into account any premium. The total extra profit to the grower last year may therefore be estimated as 12 lakhs assuming only one-eighth premium per maund.

In the present year with 120,000 acres and assuming a premium of Rs. 2 a maund and an equal yield with *desi*, *i.e.*, an average of 6 maunds per acre the extra profit will be $6 \times 2 \times 120{,}000$ equal to 14·4 lakhs. No one who knows the facts can doubt the moderation of the above estimate.

It is very satisfactory to note that this cotton is doing very well in the new Canal Colony—The Lower Bari Doab. In one

estate where 250 acres were under this cotton a total yield of close on 2,500 maunds was obtained or nearly 10 maunds per acre. It is estimated that the area under American in this colony this year will be at least 15,000 acres, of which over 10,000 will be pure 4 F.

In Lyallpur one grower this year has 2,000 acres under 4 F cotton. It may be pointed out here that not only is the seed being taken by the people from the Department but a very large and increasing number of growers are beginning to pay serious attention to improved cultivation, especially sowing in lines, and interculture—a practice so far quite unknown in the Punjab.

It may be of interest to speculate as to the possible final area of American that can be grown. The average area under cotton in the following districts where American has been successfully introduced is as follows :-

	District	Total area irrigated, 1914-15	Total area under cotton, average of 5 years	Estimated area under American cotton in 1916
		Acres	Acres	Acres
Lower Jhelum Canal ...	Shahpur ...	892,684	108,439	20,000
Lower Chenab Canal ...	Lyallpur ...	1,600,000	158,358	40,000
	Gujranwala ...	921,411	74,000	7,000
	Jhang ...	640,594	49,207	35,000
Lower Bari Doab Canal ...	Montgomery ...	670,428	20,000 (acres in 1915)	15,000
	Other districts...	......	......	3,000
	Total ...	4,725,117	410,004	120,000

As the area under cotton in the colonies is generally 10 per cent. of cultivated area, we may expect a big increase in Montgomery. The total area under cotton in the colonies will be roughly 440,000 acres, of which we may expect ultimately 300,000 acres to be under American. A certain proportion of *desi* cotton will undoubtedly continue to be grown especially in very light soils and near the tails of the canals where water conditions are precarious and late sowings are common. In such tracts probably the **Red Sanguineum** *desi* variety or perhaps a *Neglectum* type will be safer to grow.

The amount of American cotton in other districts outside the above is probably not as much as 5,000 acres, though it is being tried widely nowadays practically all over the province.

The marketing of American cotton still leaves much to be desired. The trade is mostly in the hands of Indian ginning factory owners at present, the European firms having done a comparatively small business up to date. Bombay is the chief buyer. What is curious about the business is the almost universal mixing that goes on in the ginning factories. The usual grade sent to Bombay contains from 10 to 30 per cent. of *desi* cotton. Some of the factory owners are very frank over this mixing, and the writer has often seen American cotton with 20 to 30 per cent. of *desi* being added to it before ginning, especially in the Jhang District. One reason for this is that *desi* cotton has a better colour than American and no doubt the mixture looks whiter than pure American. One would expect spinners would find the defect. Individual spinners in Bombay stoutly deny that they want such mixtures, yet that is what they mostly get and pay for.

It might be pointed out that the ginning outturn of all cottons was low last year, and thus there was more than the usual percentage of short fibre. This fact no doubt facilitated mixing with *desi*.

The dangers for the seed from this and other causes will probably make it necessary to brand 4 F bales in future. The point is receiving careful attention. It is satisfactory to note that this year as well as last year a good deal of cotton was sent pure both to Bombay and Nagpur.

The widespread growing of American cotton is brought home to any one walking in any part of the above tract comprising the Lower Jhelum, Lower Chenab, and Lower Bari Doab Canals. There is scarcely a village without a field or two of American, and in some places practically no *desi* cotton can be seen for miles. As an instance of the indirect effect of the cotton sales the case of certain large growers near Lyallpur may be mentioned. Up to the day of our first sale the best price offered to these zemindars was Rs. 10 per maund, whereas the day after the sale they were offered Rs. 11, and some actually sold privately at Rs. 11-4 a maund of *kapas*.

IMPROVED SUGARCANE IN THE UNITED PROVINCES.

BY

G. CLARKE, F.I.C.,

Agricultural Chemist, United Provinces of Agra and Oudh.

THE Sugarcane Research Station at Shahjahanpur was opened in 1913, and the work of selecting improved varieties of sugarcane was seriously taken in hand in the United Provinces. Results were obtained in a very short time.

The Research Station is fortunate in being situated near a large central factory at Rosa and since results have been available, the staff of the factory have given invaluable assistance in the distribution of improved canes and in testing the results on a factory scale.

The improved cane illustrated (Plate VII) was grown in shallow trenches, 18 inches wide and 6 inches deep with a space of 18 inches between each trench, that is, the cane rows were 3 feet apart. It was manured with castor-cake meal at the rate of 30-40 maunds per acre and irrigated by means of a pumping installation from the neighbouring river.

Before the rains it was earthed up, and it is due to this that the crop remained standing during the abnormally heavy rains and winds of the monsoon of 1915.

The importance of the latter operation cannot be over-estimated. Heavy crops of improved canes grown on the light soils of Rohilkhand that are not earthed up almost invariably fall down during the heavy rains and high winds that prevail during the monsoon in the sub-montane tracts. The quantity and particularly the quality of the *rab* and *gur* are badly affected. In fact it is

impossible to obtain the light coloured *danedar rab* and *gur*, so much prized in the bazaar, from fallen cane.

It is impossible to give an accurate figure of the cost of growing cane, as this depends on many factors that are affected by local conditions, such as cost of labour, price of oil-cake meal and cost of irrigation, etc. The trenching described above costs in the Shahjahanpur District, where labour is not particularly cheap, Rs. 15 per acre and, considering the fact that a crop of improved canes such as that illustrated will yield *gur* and *rab* worth Rs. 350 to Rs. 450 per acre, this additional outlay cannot be called excessive.

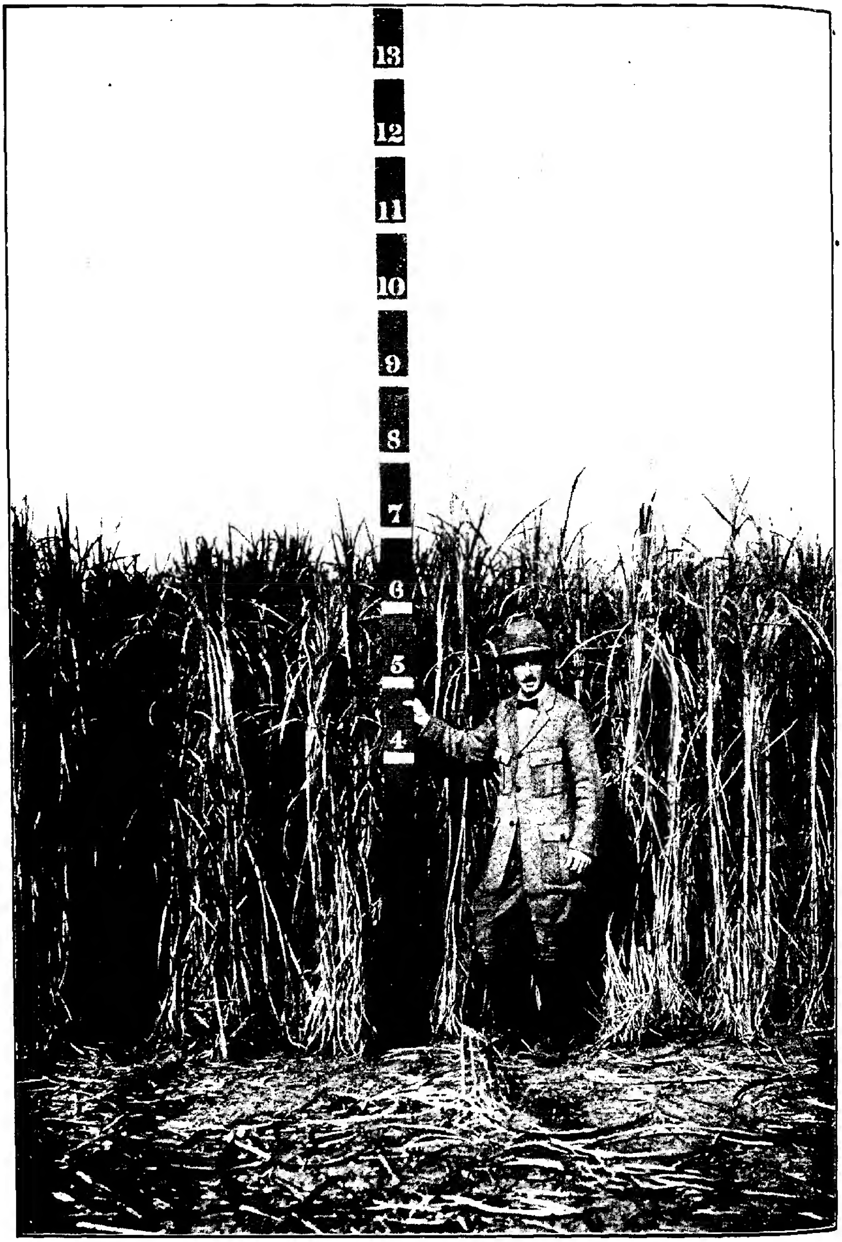
The yield of cane in the field illustrated was just over 600 maunds per acre trimmed cane, containing 11·78 sucrose per 100 cane. This was in a year when the outturn of sugar was very low, the *desi* varieties yielding 8-9 sucrose per 100 cane in this district.

The milling properties of the improved cane were tested on a factory scale in a nine roller mill capable of crushing over 500 maunds per hour. Sixty tons of cane were crushed in each test. At the author's request the milling was arranged for without the addition of maceration water in order that the results might be compared with those obtained at the Research Station on a smaller scale. The following results were obtained without maceration at the factory :—

Juice expressed per 100 cane	70·60
Sucrose per 100 juice	14·35
Purity of juice	82·00
Glucose per 100 juice	1·41
Sucrose per 100 bagasse	5·60
Sucrose per 100 cane	11·78
Mill extraction	86·00

These figures are of interest as being the first published of the results that can be obtained on a factory scale with improved canes in these provinces. As already stated, maceration was not employed and the mill extraction (86) would be increased to an appreciable extent by the use of the usual 10-15 per cent. added maceration water. These figures confirm numerous tests that have been made with this cane on a smaller scale at the Research Station with small bullock mills and small power mills.

A medium thick cane (J. 33) selected at the Sugarcane Research Station, Shahjahanpur, for distribution in the Rohilkhand Division of the United Provinces. The photograph was taken in a field grown at the Rosa Factory under the supervision of Mr. H. D. Lang.



Chunni, a local cane of the Shahjahanpur District. The photograph was taken in a neighbouring field grown at the same factory.

Another improved variety of cane, Ashy Mauritius, was grown on a large scale at the factory in 1915. It is a thick variety of the *pounda* type and can only be grown under conditions of intensive cultivation. It has been under experiment in these provinces for 10 years and has given consistently high returns both as regards yield of sugar per acre and quality of *rab* and *gur*. It requires more care in cultivation than J. 33 but it is an excellent cane, well worth a trial where proper care and attention can be given to it. It is one of the very few canes of this type that fully mature during the short growing period of Upper India.

At the Research Station it has given, through a series of years, 100-120 maunds of *rab* per acre.

The milling results obtained in a nine roller mill at Rosa in 1915 without the use of maceration water were as follows :—

Juice expressed per 100 cane	70·90
Sucrose per 100 juice	16·34
Purity of juice	88·30
Glucose per 100 juice	0·57
Sucrose per 100 bagasse	7·10
Sucrose per 100 cane	13·74
Mill extraction	84·30

The author is indebted to Mr. E. Simmons for kindly placing at his disposal for publication the two photographs illustrating this article. They were taken at Messrs. Carew & Co.'s Factory, Rosa, in the Shahjahanpur district in the United Provinces.

PHOTOGRAPHIC ILLUSTRATION.

BY

C. M. HUTCHINSON, B.A.,

Imperial Agricultural Bacteriologist.

A LARGE majority of the photographs taken to illustrate scientific writings are reproduced as half-tones, and in order to be successful as illustrations must bear certain characters which are necessary for success with this process although they may not be essential for ordinary pictorial representation as photographic prints. Half-tone reproduction of necessity reduces contrast and in many cases eliminates fine detail, so that it is necessary to aim at a negative in which contrast will be exaggerated, and to produce one on such a scale as will allow the smallest detail required to be shown in the final illustration, to appear sufficiently marked to avoid elimination. This is especially the case with such subjects as include written characters or figures, which in many instances become entirely illegible in reproduction through reduction in scale. It may be well here to point out the advisability of including, in many subjects, a scale of inches or feet, or some object of standard size such as a watch, or for outdoor subjects a figure, without which many photographs both in text-books and scientific memoirs lose illustrative value. For half-tone reproduction what is called a "hard" negative is preferable to one showing fine gradations of tone merging into one another; hardness in this sense means a sharper definition of the edges of the high lights and a greater obvious contrast between the high lights and shadows. Such hardness is entirely wrong in pictorial photography, where the object aimed at is the rendition of atmosphere by means of a fine scale of gradation between the

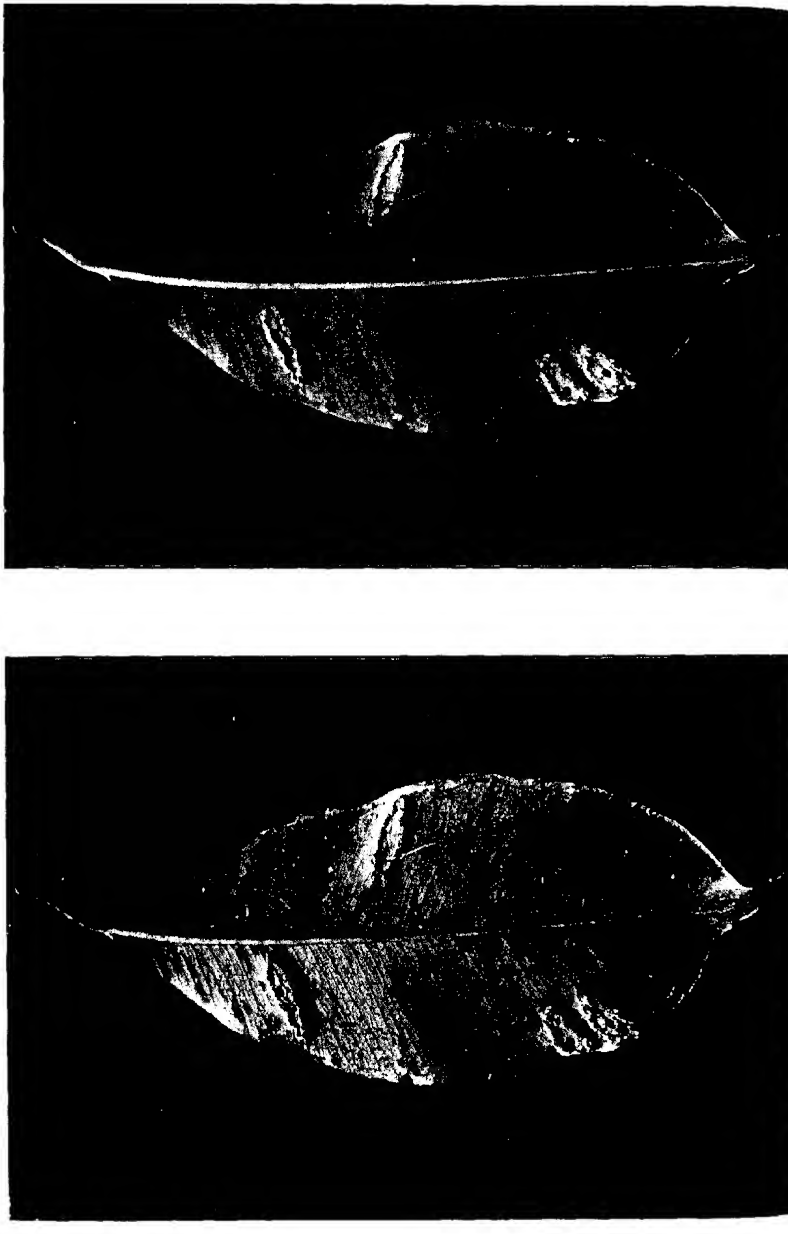
WHEAT PLOTS.

(a) TAKEN AT MIDDAY JANUARY 25TH.

(b) TAKEN AT 4 P. M.

To show advantage of using evening light.

Plate.



INSECT GALLS ON LEAF

various tones of the picture, this result being attained largely by adapting the style of the negative to the process of printing or *vice versa;* when P. O. P., Bromide, Carbon or Collotype are admissible an entirely different class of negative can be aimed at, but for half-tone reproduction of such subjects as generally come into scientific papers, a soft, evenly gradated negative is not desirable, but rather a hard, vigorous one. It must also be remembered that owing to the "grained" character of the half-tone block, no great range of tone is admissible in pictures to be reproduced by this process, so that in taking out-of-door subjects due allowance must be made for the loss of vigour resulting from the compressed scale of tones. It is unfortunate that in India other more truthful processes such as photogravure and collotype become so expensive, on account of the climate, that they cannot be made use of in our publications so long as considerations of convenience necessitate the use of illustrations produced in this country. It is also to be remembered that the limitations of the half-tone process in many cases render it advisable to make use of line block reproduction in preference thereto. The class of negative suitable for half-tone reproduction can be got in various ways, the chief points to attend to being (1) lighting, (2) exposure and development, (3) class of plate and use of light filters.

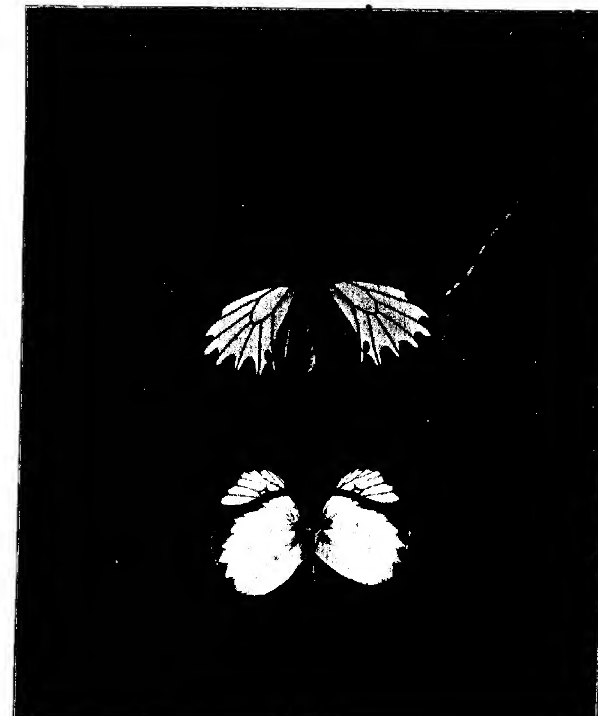
Lighting. This is not always under control, but it is generally possible to select a time of day when the subject will be lighted from the side rather than from directly overhead; *i.e.*, the morning or evening rather than midday which in most cases in outdoor subjects will give better contrast. In nearly every case a study of this point will reveal the best time of day for obtaining a vigorous negative, and one which will show those characteristic features of the subject which it is desired to bring into prominence (Plate IX, fig. (*b*), Wheat Plots).

In many cases, such as that illustrated in Plate X (Insect Galls on Leaf) side lighting in place of diffuse or direct illumination is essential for successful representation of the object.

Exposure. This is of paramount importance, as is of course generally recognized, and it is only referred to here on account of the

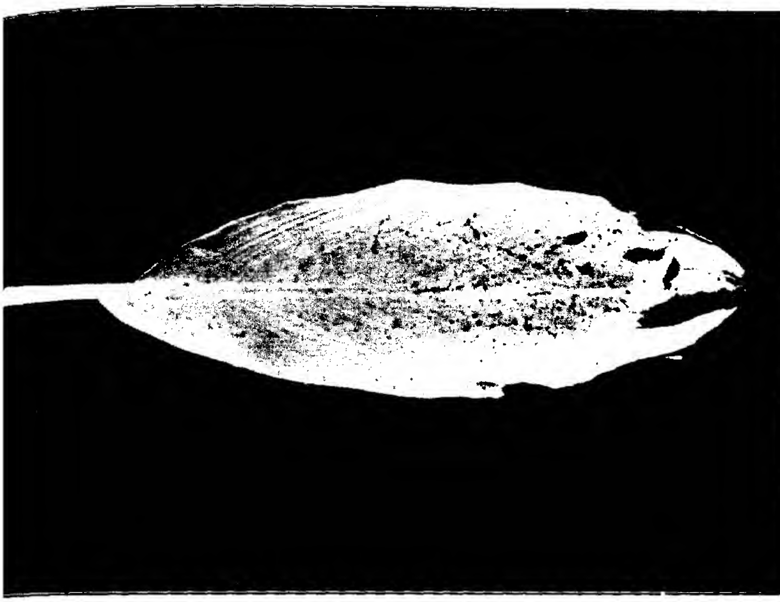
apparently very general failure to avoid serious errors in this respect; the commonest fault, in the writer's experience, tends to be over-exposure combined with the natural corollary of under-development; this is not so bad a fault as under-exposure and over-development (although the results are very similar) since the photographer is generally unable to stop development before so much of the picture has appeared as will allow of considerable improvement by intensification at the hands of the reproducer. The writer has noticed that a considerable number of amateur photographers in India have so little confidence in their power of correctly estimating exposure that they habitually commence development with only half the quantity of accelerator recommended by the makers of the plate in their carefully calculated developer, and as most of the plates are over-exposed, development is finished with this half strength solution. The resulting negatives are in many cases regarded as good ones by their authors, but they are not of such good quality as would have been attained either by a shorter exposure and development with full strength developer, or with the same over-exposure and development with full strength developer restrained by pot. bromide. It is therefore generally better to give a full exposure, in case of doubt as to how much should be given, and use full strength developer with bromide rather than the method referred to above. The resulting negative is generally hard and the contrasts are sometimes somewhat too violent for the best pictorial effect in ordinary printing, but for half-tone reproduction this is a fault on the right side, provided the hardness is due to slow development and not to under-exposure. It may not be out of place here to draw attention to a point which is liable to escape the notice of those who may have had a considerable amount of successful experience with such open subjects as more generally attract the amateur photographer; when photographing a single object such as a plant in a pot, due allowance is sometimes not made for the very great increase in exposure required by the heaviness of the shadows in such a near object as compared with that of such shadows when a similar plant forms only a small part of the picture in an outdoor subject. For the same reason it is all the more necessary to make

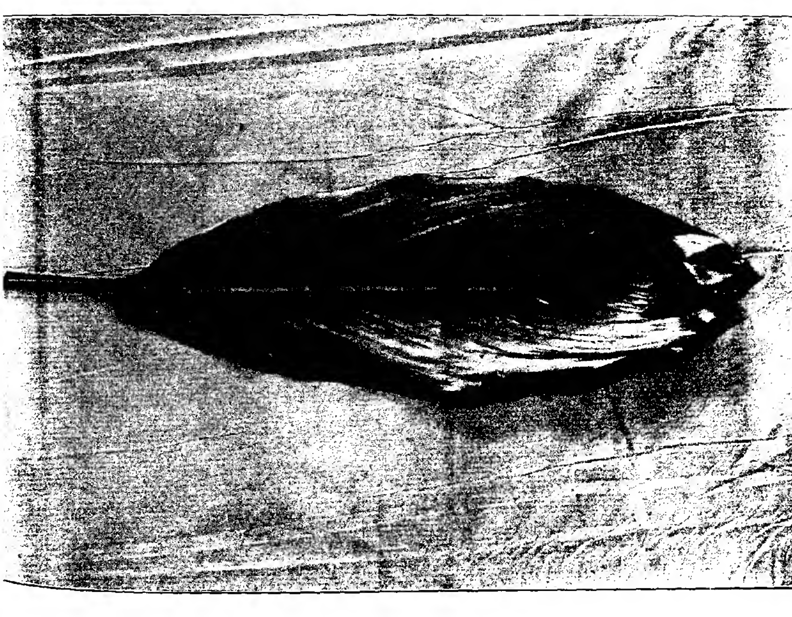
(a) ILFORD ORDINARY.



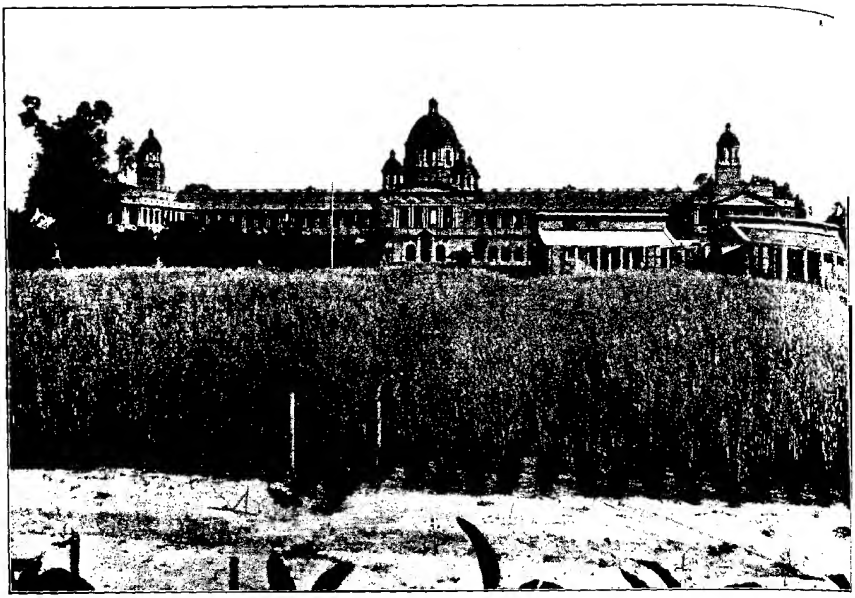
(b) WRATTEN M PLATE AND YELLOW SCREEN. WRATTEN K 2.

To show necessity for use of Orthochromatic plates for such coloured subjects. Upper butterfly has orange-yellow underwing; lower butterfly is sulphur coloured.

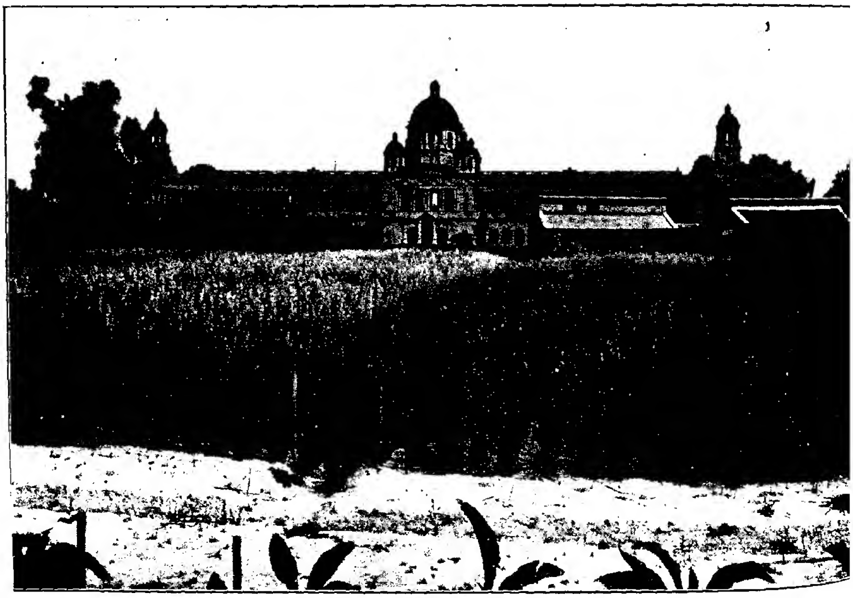




OAT PLOTS.



(a) ILFORD ORDINARY.



(b) WRATTEN M PLATE AND RED SCREEN. (WRATTEN A).

Over correction to show yellow on green.

such allowance when photographing an object (such as a single leaf) so as to reproduce it very nearly life size.

Class of plate. This implies various alternatives, such as slow or rapid, ordinary or orthochromatic, backed or unbacked plates. Films need not be considered, as they are not only expensive but are extremely unreliable in this climate. Generally speaking, slow plates are to be preferred to rapid ones, not only on account of their comparative ease of development and the brilliant negatives which can readily be got from them, but because of the very great latitude of exposure which they permit. This is an inherent quality resulting from their method of manufacture, but is also partly due to the fact that, owing to the comparatively good light in which they can be developed, control of this operation is simplified. Provided a slow plate is not under-exposed a good negative can be obtained from it, under almost any other conditions of exposure, even up to ten or more times that necessary to produce the best result, and as most agricultural subjects admit of time exposures of considerable duration, the use of slow plates may be recommended in preference to fast ones whenever possible. Even in photographing out-of-door subjects which may be affected by wind movement, it may be pointed out that, by stopping down and giving a sufficiently long exposure, a moving branch or crop will, except when the wind movement is considerable, appear sharp in the resulting negative. Furthermore it is very generally true that slow plates are not so liable to deteriorate in the Indian climate as are faster and especially orthochromatic ones, nor do they exhibit so much tendency to suffer from chemical fog due to high temperature of the developer as is shown by the latter class of plate. It is perhaps unnecessary to speak of the greater liability to light fogging which accompanies the use of extra rapid plates, although it may be mentioned as perhaps not being generally known that this may take place through some parts of the materials of the camera and dark slides in bright sunlight, especially the hinged part of the shutter of the dark slide and the leaves of between-lens shutters, which allow a considerable amount of red light to pass through them when made of vulcanite, as they frequently are. It is also worthy of note that slow plates give negatives of much

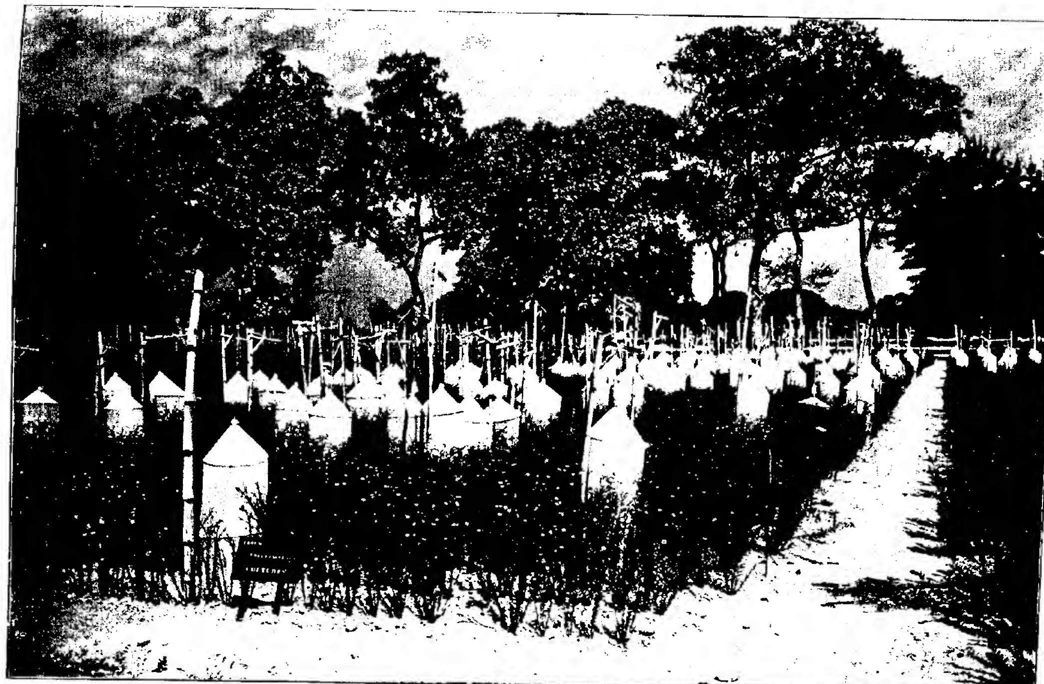
finer grain than do rapid ones, and this is an important distinction when lantern slides or enlargements are to be made from them. A good many subjects, however, require the use of fast plates in order to enable shutter exposures to be made, and in this connection it might be well to point out the advantages of the small hand camera as being suitable for many subjects which do not demand representation of fine detail but are merely intended to help a written description by pictorial illustration. Many such subjects (*see* Frontispiece) will be found photographically reproduced in the publications of this and other Agricultural Departments, and it may be said that a large percentage of them could have been taken with equal photographic success either on such a small plate as is used in various makes of hand camera or on larger ones such as half plate, but it should be noted that in most cases it would have been very much easier to obtain good results by using the smaller plate, partly on account of the great depth of focus of the short focus lens fitted to small cameras, and partly by reason of the greater number of alternative exposures which it is generally possible to allow when carrying such small apparatus. With regard to the focal length of lenses, it may be pointed out that, although those of short focus possess the advantage of depth of focus, with the accompanying power of giving short exposures at full aperture, this is in many cases more than counter-balanced by the necessary accompaniment of exaggeration of perspective which makes their use inadmissible for such subjects as field crops and experimental plots. On the other hand, for photographing live-stock, especially single specimens, and in cases in which an object in the foreground is to be the subject of interest, a small camera and short focus lens has many advantages, especially when lantern slides are to be made, which can then be done direct without reduction. When views of more extended subjects are required a more just appreciation of the relative sizes of objects in a picture is of course obtained by the use of a long focus lens, and it may be said that for a large class of subjects the use of a telephoto lens will give results very much superior in every respect to those obtainable with the ordinary lens whose focus bears the usual ratio to the diagonal of the plate. Moreover the modern telephoto lens is no longer the

PLATE XIV.

ILFORD ORDINARY

PLATE 2

LINSEED PLOTS.



WRATTEN M PLATE AND YELLOW SCREEN. (WRATTEN K.)

To show value of Orthochromatic Plate for rendering detail in green crops.

cumbersome and complicated addition to the camera of a few years ago, but is self-contained, not unduly heavy, and is simple to use ; it must not be supposed that its only value is for taking objects necessarily distant ; its use for the photography of field crops allows of the representation on the same plate of adjacent plots under differential treatment or bearing varieties of crops, without destroying comparison or contrast by the introduction of the exaggerated perspective almost inseparable from the use of the ordinary lens. A further advantage of the telephoto lens lies in its use for photographing single objects, such as plants, in such a way as to separate them from their surroundings, especially the background. This is the natural result of taking a large scale photograph of such an object with a telephoto lens, which, owing to its design, fails to define any objects except those lying in the single plane for which it is focussed, when used at a large aperture and brought near the object. In the many cases, where the use of an artificial background screen is impossible or difficult, this property is of great value, especially when half-tone is to be used, as any slight differentiation of the background from the subject which may exist in a photograph, is frequently lost in this method of reproduction.

It must be remembered that in reproducing a photograph for illustration it frequently happens that reduction in size of the original is effected in order to save space. In choosing the size of camera and plate this fact should be kept in mind, as whole plate photographs are very generally reduced to half plate size with accompanying loss of detail, so that it may be suggested that the use of a half-plate camera will generally be found advisable in preference to the larger size.

Whilst dealing with lenses it may be well to point out a fact in connection with the use of modern anastigmats which may not be generally known. It is very natural for the photographer to assume that having paid a long price for a good lens, such as an anastigmat, he will find it easier to produce good results than with the old-fashioned Rapid Rectilinear. In England this is generally the case, but in India, where most of our photographs are taken in bright sunlight, we not only lose the principal advantage of the anastigmat, which is designed to enable pictures to be taken in

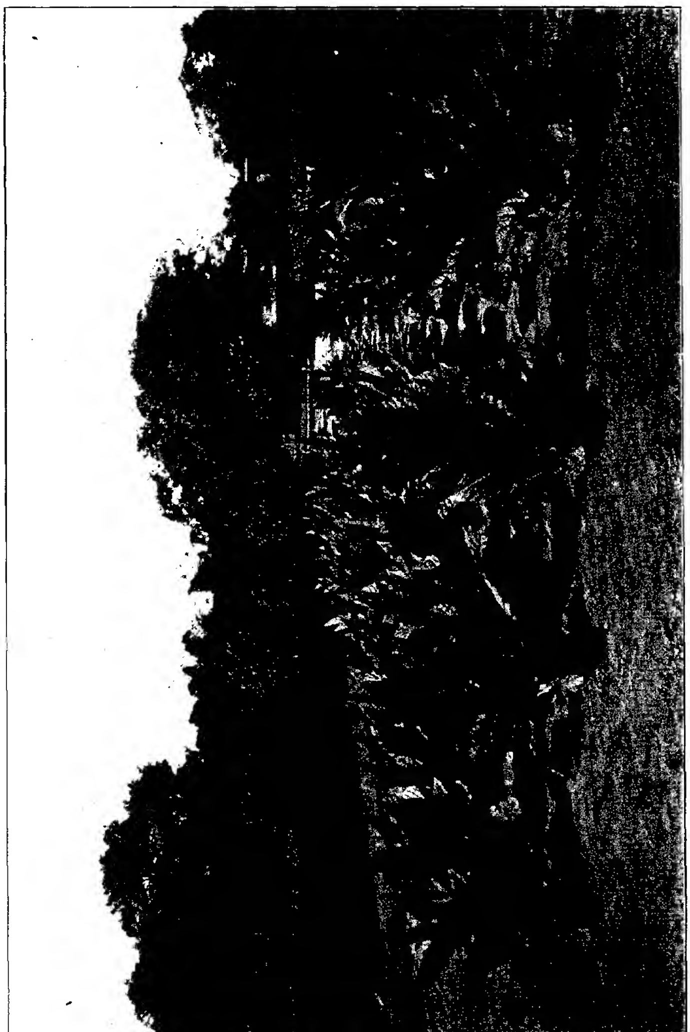
comparatively poor light by the use of large apertures, but also encounter the disadvantage of "flare;" this is, roughly, the intrusion of sky light by internal reflection in the lens, into parts of the picture where it should not appear, the result in bad cases being patches of light known as flare spots, and in less pronounced ones of general light fog, which gives the impression of over-exposure when developing, and causes many photographers to stop development too soon to allow of the production of contrast. This effect can be avoided by sufficient care in selecting the point of view with reference to the position of the sun, but it may most easily be overcome by the use of an auxiliary lens-hood, the ordinary one supplied with most anastigmats being made, for appearance sake and convenience, much too shallow for safe use in this country. This accessory may be described as almost indispensable in outdoor work in India in connection with most anastigmats, especially when working at or near full aperture.

The advantages of using backed plates are so well known that it is unnecessary to do more than say that many photographers admit their utility but do not use them, partly on account of difficulty in obtaining them, but largely because of fancied trouble in developing them ; the latter is really inconsiderable with a good make of plate which can be put straight into the developer without removing the backing, this being got rid of whilst rinsing the plate before fixing. On the other hand, the very great superiority of negatives of outdoor subjects including any strong high lights and still more so of photomicrographs, when taken on backed plates, renders their use almost imperative for such subjects, and not only for interiors including windows, or trees and shrubs against the sky.

Orthochromatic Plates. It is unnecessary to say anything as to the theory underlying the use of orthochromatic plates, but it may be of interest to give some examples of their value, and indeed of their occasional indispensability in illustrating such subjects as are photographically reproduced in agricultural publications. Incidentally it may be remarked that many orthochromatic plates now on the market have a very limited value owing to their comparative insensitiveness to the yellow and red end of the

PLATE XVI.

TOBACCO.



ILFORD ORDINARY.

WRATTEN M PLATE AND YELLOW SCREEN WRATTEN K$_{1\frac{1}{2}}$.

This is a very difficult subject on account of the heavy shadows on the leaves. It will be seen that these are much more accentuated by the ordinary plate for reasons described in the text.

spectrum, and, where orthochromatism is an advantage, as it is in such a large percentage of cases, it is nearly always worth while to make use of a panchromatic plate. Given correct exposure, a clock, and a thermometer, no more difficulty need be experienced in the development of panchromatic plates than of any others of the orthochromatic variety, and although, as has been pointed out before, the ordinary plate of slow speed is easier to use and may be generally recommended for this reason, no scientific worker will be satisfied to use such plates when convinced that the best photographic representation of an object can only be obtained by means of an orthochromatic plate. Using a panchromatic plate, a light filter may be selected which will correct the superior actinic power of the blue end of the spectrum so as to give correct visual rendering of the subject. Thus in Plate XI fig. (b) the yellow of the butterfly wing is brought out by the use of a deep yellow screen; similarly in Plate XII fig. (b) the black fungal spot on the yellow leaf requires similar colour correction.

In some cases over-correction may be necessary to ensure the appearance of slight colour differences which would otherwise disappear in half-tone reproduction. Plate XIII fig. (b) shows such over-correction due to the use of a red screen; had a yellow screen been used the difference between the ripe and unripe crops although obvious in the negative would not be so in the half-tone reproduction.

One of the most valuable properties of the orthochromatic plate is its power of improving the representation of a field crop without special reference, as in the above cases, to obvious colour differences. This is shown in Plates XIV and XV. It may be of interest to point out why this is so and the reason is made more clear by consideration of the second example (Tobacco Plates XVI and XVII.) Much of the light reaching the lens, in this case, has come through the thickness of the leaves of the crop and, as transmitted light, has undergone absorption, losing some of the blue end of the spectrum. For this reason the ordinary plate can make but little use of it, so that many leaves and portions of leaves which appear well illuminated in the orthochromatic plate are in deep shadow in the ordinary plate, owing to the absence of any large quantity of

reflected light. It may perhaps be relevant to point out that an exposure of sufficient duration to give full value to these heavy shadows, would have resulted in over-exposure of the high lights. In this particular case the use of a panchromatic plate even without any filter would have given a better picture than the ordinary plate, but the additional correction afforded by the yellow screen levels up the shadows and tones down the high lights. A further difference between the rendering power of the panchromatic and the ordinary plate is due to the fact that the light coming from shadowed portions of such subjects as the above is frequently less rich in blue rays and will consequently have less actinic value.

It is useful to remember that orthochromatic rendering may be spoilt by over-correction which may result in *isochromatism*, that is by giving all the colours of the subject an equal luminosity value and thus producing an unnatural effect. This is illustrated in Plate XVIII where the best rendering is obtained on the ordinary plate, the yellow screen used in fig. (b) being too deep in tone and, by reason of its sharp cutting out of the blue end of the spectrum, producing over-correction, and as described above, reducing the shadows in this case to insignificance.

Where adequate representation of an object depends upon accentuation of shadow detail and of contrast between light and shade rather than upon orthochromatic rendering, the use of colour sensitive plates should be avoided as tending to flatten the object by reducing contrast. An example is given in Plate X where oblique illumination is also necessary to give solidity and relief to the representation.

Plate XIX illustrates the value of light filters for producing contrast in photomicrographic representation of objects including fine detail in thin sections, such as the cell walls in the subject reproduced, which without this aid are imperfectly represented. The selection of the appropriate filters must be made with reference to the stains used in the subject.

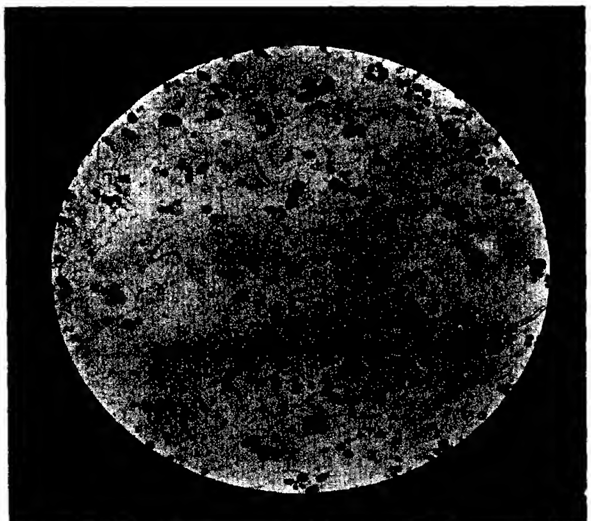
In conclusion it may be reiterated that for half-tone reproduction a really vigorous photograph is necessary and in order to obtain this the first essential is correct exposure. Until a large amount of

(a) ILFORD ORDINARY.

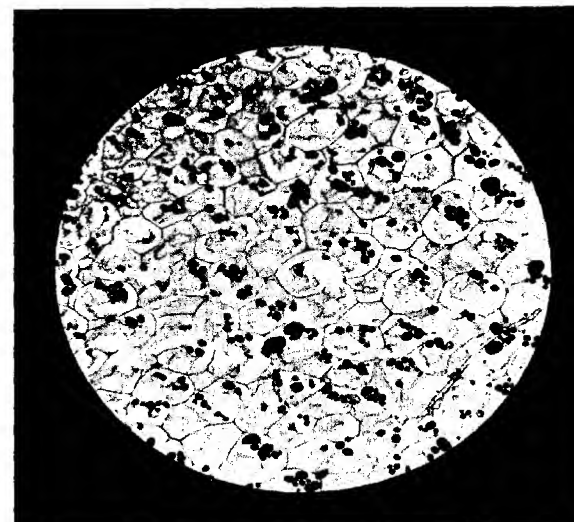
[illegible]

Plate XIX.

PHOTO-MICROGRAPH OF SECTION OF POTATO TUBER.



(a) NO SCREEN.



(b) GREEN AND YELLOW SCREENS. (WRATTEN B & E).

Stained Saffranin and Haematoxylin Watson 16 m.m. object. Wratten M plate.

Photo., Engraved & printed at the Offices of the Survey of India, Calcutta

experience of photographing subjects similar to the one to be reproduced has been obtained, no photographer can correctly estimate, by guesswork, the proper exposure, and the writer would suggest as absolutely necessary for attaining such experience, the use of a large number of alternative exposures with careful notes of the results; these notes should be kept for reference and use in the future and will be found invaluable. An exposure calculator such as the "Wellcome" supplied by Messrs. Burroughs Wellcome & Co., with their photographic note book, is also most useful, whereas exposure meters depending upon the use of light sensitive paper are practically worthless in India. Standardization of materials and methods by cutting down the number of uncertain factors is also of value; thus the invariable use of one make of each kind of plate required, one kind of developer, and even, so far as is possible, of one lens aperture, will be of help in obtaining results of even value. As a matter of personal experience the writer may strongly recommend the method of development advocated by Messrs. Wratten & Wainwright which does away with inspection of the plate during development, and depends merely upon carrying this on for a length of time determined by the temperature of the developer, the speed of the plate, and the class of negative required, in accordance with a table supplied with each box of plates by this firm. It is claimed that this method will give the best results irrespective of exposure, and with this claim the writer's experience ie in agreement; in addition it may be said that the error of under-development referred to previously will be avoided by this means. With regard to temperature and the special and very serious troubles connected with photography in India arising from this cause, it may be said briefly that when the developer temperature is high the use of pot. bromide becomes necessary and the use of such developers as metol and rodinal whose tendency to produce soft negatives is accentuated under these conditions, is of doubtful expediency. Alum should be freely used, but if ice is available it must be remembered that although a low temperature developer is an advantage, the tendency to frilling is greatly increased by any serious differences in the temperatures of the various solutions through which the plate passes.

THE MANURIAL VALUE OF POTSHERDS.

BY

ALBERT HOWARD, C.I.E., M.A.,

Imperial Economic Botanist, Pusa.

1. Introduction.

In previous papers,[1] dealing with certain aspects of soil aeration and surface drainage in India, reference has been made to the effect of adding to the soil porous substances such as potsherds (*thikra*) and fragments of bricks (*rora*). The occurrence of such materials, in sufficient quantity, in a fine alluvial soil has been found at Pusa to exercise a profound influence on the development of the plant and on the yield. Grown on such soils, leguminous crops like gram (*Cicer arietinum*) and Java indigo (*Indigofera arrecta*) produce a deep and copious root-system with abundant nodules as well as heavy crops of well filled seed. Tobacco, when raised on soil rich in potsherds, develops a great mass of fine roots and a heavy yield of leaf. If green-manure is added to such land during the monsoon, the succeeding *rabi* crops benefit markedly.

The explanation suggested to account for these results is a simple one and is based on the fact that the roots of plants as well as the soil organisms require not only a large oxygen supply but also some means of getting rid of the large quantities of carbon dioxide they produce in the soil. Potsherds improve the aeration of alluvial soils and thus afford the means of an increased supply of oxygen and nitrogen in one direction and of the escape of carbon dioxide in the other. When a crop like *sanai* (*Crotalaria juncea*) is ploughed into the ground during the monsoon, a large amount of oxygen is

[1] Soil ventilation, *Bulletin 52, Agricultural Research Institute, Pusa,* 1915, and Soil aeration in Agriculture, *Bulletin 61, Agricultural Research Institute, Pusa,* 1916.

required to complete the decay of the green-manure and vast quantities of carbon dioxide are produced. If this decay is not completed by the time a *rabi* crop is sown, there is present in the soil another competitor for oxygen and another producer of carbon dioxide in addition to the soil organisms and the growing crop. Hence want of oxygen and excess of carbon dioxide may become limiting factors in growth and this would explain why it is that green-manuring so often fails on alluvial soils unless they are surface drained and unless the soil is rich in potsherds. Simple as is this explanation, its complete proof, by the ordinary methods of academic research, is not without difficulty. Several factors, interacting on one another, are involved in such investigations—the plant, the soil, the organisms in the soil, the amount of soil moisture present, the composition of the soil atmosphere in the pore spaces and the nature and amount of the gases and minerals dissolved in the water films surrounding the soil particles. Some of these factors are also influenced by the temperature. To trace the various changes in composition of the atmosphere in the pore spaces and of the dissolved gases in the thin films of water which bathe the root hairs of the plant are matters of the very greatest difficulty. Analyses of the air aspirated from the soil only tell us the average composition of the soil atmosphere. Such methods are obviously far too crude for investigating the changes in the gaseous content of the water films and the relations between this dissolved gas and the general soil air.

While the complete elucidation of the parts played by oxygen and carbon dioxide in the soil are likely to prove both time-consuming and laborious, the fact remains that a considerable amount of evidence exists in favour of the rôle of the potsherd as an aerating agent and of the practical value of this method of soil improvement. It is proposed to refer to a portion of this evidence in the present paper in so far as it relates to the manuring of crops.

2. The waters of Jais.

In February 1915, in the course of a journey through Oudh, some excellent tobacco cultivation was noticed near Jais in the

District of Rae Bareli. Jais is an old Mohammedan city, standing high above the surrounding plain and the mounds on which the town is built are composed of the remains of the ancient city of Udianagar. Large stretches of very fine tobacco (*N. rustica*) are grown on the lower land surrounding Jais and the crop is irrigated from wells. In the present year, I again had occasion to pass Jais and took the opportunity of examining the tobacco cultivation. The soil was rich in potsherds, derived no doubt from broken roof tiles and water pots, and the water used in irrigating the tobacco was said by the cultivators to be unfit for drinking but very good for this crop, in the growth of which they stated very little manure was used. This was remarkable considering the excellent crops and the fact that this plant will not thrive in the absence of abundant nitrogenous food materials. They said the well water was rich in saltpetre and that as many as fourteen waterings are often given to tobacco. A large sample of irrigation water was taken from a well standing in the centre of the tobacco area about a quarter of a mile from the nearest houses, the analysis of which has been carried out by Mr. J. Sen, Offg. Imperial Agricultural Chemist at Pusa who has also kindly furnished me, for comparison, with some analyses of well waters at Pusa. The results are as follows :—

TABLE I.

Analyses of well water from Jais and Pusa.

	Jais	Pusa
Magnesium carbonate	25·39	7·6 to 15·200
Calcium carbonate	—	15·9 to 25·000
Magnesium sulphate	10·89	Nil to 1·550
Calcium sulphate	45·50	—
Sodium sulphate	1·01	Nil to 8·300
Sodium carbonate	—	4·0 to 9·9.0
Potassium nitrate	34·57	Nil to 0·036
Sodium nitrate	16·55	
Potassium sulphate	—	1·8 to 5·400
Sodium chloride	45·27	0·9 to 1·600
Total solids	179·09	30·2 to 66·986
Ammonia (free)	0·0212	Nil to 0·032
Ammonia (albuminoid)	0·0143	0·004 to 0·039
Oxygen dissolved	0·7250	0·067 to 0·153

(The numbers refer to parts in 100,000).

Two facts stand out very clearly in these analyses—the high proportion of nitrates in the Jais irrigation water and the amount of dissolved oxygen. In comparison, the Pusa well waters are markedly deficient in these substances. The Jais wells are situated in land exceedingly rich in potsherds, where the aeration of the soil is copious and where there is abundant oxygen for the complete decay and nitrification of the organic matter. It is therefore easy to understand how this well water comes to be rich in nitrates and in dissolved oxygen and why it is so much valued for irrigating tobacco. At Pusa, on the other hand, the alluvium is fine and close and soil aeration is difficult. Here the well waters are poor both in nitrates and in dissolved oxygen and do not possess any particular manurial value. The Jais water, in addition to its high content of nitrates and oxygen, is also rich in potash. This can be accounted for, partly by the fact that in rural centres wood and cowdung are used for fuel and partly by the increased aeration of the soil surrounding the wells due to the quantity of potsherd present. There is considerable evidence for the belief that one of the functions of the fungi of the soil is to collect phosphates and potash for the use of the higher plants.[1] These fungi can only work in the presence of oxygen and therefore the better and deeper the soil aeration the more potash they collect and render available.

Irrigation water, rich in potassium nitrate, is by no means the only condition necessary for raising heavy crops of tobacco of good quality such as the Jais product is said to possess. The soil must also have the proper physical condition for abundant and rapid root development and its tilth must be such that it is not destroyed by frequent surface flooding. Moreover, the crop must be provided with sufficient phosphates as little manure is added to the soil. The presence of abundance of potsherds in the soil would prevent the destruction of the tilth by irrigation and would also facilitate thorough drainage and thus promote aeration. This in turn would provide the soil fungi with oxygen and thus assist indirectly in the collection of phosphates for the tobacco.

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[1] Marshall Ward, *Disease in Plants*, 1901, pp. 56 68

The Jais tobacco fields can be regarded as a natural manure factory in which nitrates, potash and phosphates are produced in sufficient quantity for crops like tobacco, maize and poppy which are all grown on the lands in question. In spite of the fact that maize is followed by tobacco or poppy the same year and that a relatively small amount of manure is used, the tobacco crops are luxuriant and the cultivators are obviously prosperous and well-to-do. The sources of the nitrogen and minerals used by the crops are evidently the crop residues and the manure supplied for the maize crop. That this organic matter produces such excellent results is, in all probability, a consequence of the copious aeration of the soil produced by the great numbers of potsherds present. That the crops do not make use of all the nitrates formed is seen by the composition of the well water used in irrigation.

3. Some other Indian nitrate factories.

The potsherd area round Jais is by no means the only natural nitrate factory in India. Well waters, rich in nitrates, occur elsewhere near villages and towns in the plains of India and also in Gujerat.[1] In all cases the aeration of the soils round these nitrate containing wells is good and, in many instances, potsherds or brick refuse occur in large quantities in the immediate neighbourhood.

Natural nitrate factories are common in some tracts of India in the absence of wells. Thus in North Bihar, the manufacture of potassium nitrate is a well-known industry and as many as 20,000 tons of this substance are produced annually.[2] The saltpetre is formed in the so-called nitrous earth and is separated by the *nunias* from other salts which occur mixed with it. This nitrous earth is found mostly *on the high lands round the villages which contain potsherds or brick fragments.* The potassium nitrate is derived partly from organic matter and partly from the ashes of wood or cowdung produced in large quantities in the villages. The abundant soil aeration brought about by the potsherds provides the necessary oxygen for the soil organisms including the nitrate

[1] *Agricultural Ledger*, no. 14, 1895.

[2] *The Commercial Products of India*, 1908, p. 972.

producing bacteria. In the presence of organic matter, wood ashes and moisture and under temperature conditions which favour intense bacterial activity, nitrification is rapid and potassium nitrate is produced in abundance. The evaporation of the surface moisture during the dry season, combined with the rise of the subsoil water by capillary action, leads to an efflorescence of saline matter on the ground in which saltpetre is one of the chief constituents. Such accumulations of salts, rich in nitrates, largely occur in areas where potsherds are abundant and are naturally quite different from those met with in alkali lands. One factor, however, which obviously limits production, has hitherto been forgotten in considering these natural nitrate factories. This is the aerating value of the potsherd and the fact that without a copious air supply, rapid nitrification is impossible in the soils of North Bihar.

4. Some practical applications.

The practical applications of these facts to Indian agriculture must now be considered.

The manuring of wells. As is well known, there is a large area of intensive cultivation surrounding the towns and cities of India where large crops of vegetables, sugarcane and tobacco are grown under well or river irrigation. Manure is obtainable, and potsherds are abundant. The manure is usually added to the soil but no use is made of the potsherds. More could be got out of the present supplies of manure and this garden cultivation could be extended by dressing the land with the potsherds and by using some of the organic matter for manuring the wells. It would not be a difficult matter to make, in the soil round a well, a potassium nitrate factory the products of which could be directed either into the well itself or into the irrigation stream. The soil round the well would have to be mixed with the right amount of potsherds and organic matter and ashes would have to be added to the surface soil from time to time. The details would have to be worked out experimentally and then applied to actual working conditions. Possibly some Chemist in the Agricultural Department in search of an interesting problem might consider this question.

The permanent improvement of the land. It is evident that in the soils of India, the great factor in manuring is aeration and that Jethro Tull's great generalization that "Cultivation is manuring" can now be extended and summed up in the phrase—*Manuring is aeration.* The potsherd enables us permanently to aerate the soil and thus make the best use of organic matter including green manures. The potsherd by itself has only a limited value but with the help of small quantities of organic matter, extraordinary results are possible as the example of Jais is sufficient to indicate.

Preliminary experiments have already been completed in the Botanical Area at Pusa which prove that, in the growth of tobacco after green manure, the addition of potsherds to the soil is profitable. With potsherds and surface drainage, a yield of 24 maunds to the acre of cured tobacco leaf has been raised on green manure alone and the produce, cured on the ground in the country fashion, has been sold to the Indian Leaf Tobacco Development Company at Dalsing Serai for fifteen rupees a maund. The value of the crop was therefore three hundred and sixty rupees an acre. To prove the manurial value of potsherds however, something more than small trials at a Plant Breeding Station are required. Accordingly, arrangements have been made to treat ten acres of land on the Dholi estate with potsherds and to compare the produce of the land for some years with the initial capital cost of the treatment. There is little doubt that the results will establish this method of soil improvement and will suggest a useful means for the investment, in the soil of India, of much of the capital now lying idle in the country.

DRY-FARMING AND ITS POSSIBILITIES IN INDIA.

BY

C. V. SANE, B. Ag. (Univ. of Bombay), M. Sc. (Univ. of Wisconsin).

Foreword

Less than a generation ago the very large area of land in Western America, not susceptible of irrigation, was looked upon as practically worthless for agriculture. Since that time many millions of acres of these apparently inhospitable tracts have been converted into fruitful fields. This is due in part to the venturesome energy of the American people, but chiefly to the careful investigation of the natural conditions of the territory in question and the application to the land of well-known scientific principles, followed by further investigations leading to the discovery of other principles, of profitable application to the reclamation of non-irrigable arid lands.

Colorado established, more than eighteen years ago, a branch station for the study of dry-farming. Utah, a few years later, established a large series of experimental dry-farms, and inaugurated a series of studies on the relation of soils and crops to water. Other states have done similar work, and the Federal Government has conducted for some years very comprehensive dry-farming studies in the great plains area of the United States. On the basis of such work the American people have been able to conquer, without irrigation, much of the great territory lying under a light rainfall in what was formerly known as the Great American Desert.

In talking with students from India it has always seemed that, while the problems of India no doubt differ considerably from those

of western United States, the same process of careful study of existing conditions and the wise applications of scientific principles, old or new, should make it possible to make the agriculture of India, not under irrigation, much more certain than it has been formerly. The problem is a large one, whether in India or America, but the experience of western America leads most of us who have been engaged in the work, to believe that the methods of study followed so successfully in reclaiming the American arid lands may be employed with success wherever a low or uncertain rainfall is a determining condition.

Mr. C. V. Sane, the author of this paper, has spent much time in the dry-farming areas of the United States and has had unusual opportunities to become acquainted with the methods practised on American dry-farms and in dry-farming laboratories. His description of American dry-farming is accurate. He has emphasized the leading principles of the practice. It is to be hoped that the dry-farming regions of India may be helped by such studies and discussions as this one by Mr. Sane, and that especially they may lead to an enlargement of the scientific study of dry-farming under the conditions of India. We of the far west may thus learn much of the far east, and we still have much to learn.

LOGAN, UTAH, U.S.A.
October, 1915.

JOHN A. WIDTSOE.

Introduction.

OF the many things that compel the attention of agricultural investigators in India towards American agriculture, one thing that has done more so than any other is the system of dry-farming and its success in such a short time. By the very nature of things in most cases the little knowledge that we have on the subject is principally derived from books and consequently is very rudimentary. For though the principles of dry-farming are known all over the world the art of manipulating the soil so as to make it an economical practice is fraught with many difficulties. The necessity of dry-farming in India is becoming more and more apparent every day.

However, a detailed study of all the factors—chiefly soil and soil moisture—that are associated with its success in parts where it is an established practice should logically precede the undertaking of such an investigation.

The writer has not only made a careful study of the literature on the subject but has also had the privilege of conferring with persons whose opinions are an authority in the matter, in addition to visits and observations in the fields. A few figures dealing with mechanical analysis, moisture study, etc., have been introduced, for, apart from rainfall which can easily be ascertained, these are the most important factors, knowledge of which is not so easily available in India. They illustrate the basis and extent of the system and will prove of great help in laying out the work. For after all is said and done elsewhere the only way things can be answered definitely is by independent experimenting.

That dry-farming is a world problem is now universally conceded. The following table taken from "Dry-Farming" by J. A. Widtsoe illustrates this fact.

Character of farming	Annual precipitation	Proportion of earth's land surface per cent.
Arid	Under 10"	25·00
Semi-arid	10" – 20"	30·00
Sub-humid	20" – 30"	20·00
Humid	30" – 40"	
,,	40" – 60"	11·00
,,	60" – 80"	9·00
,,	80" – 120"	4·00
,,	120" – 160"	0·50
,,	above 160"	0·50
		100

It will be seen that 55 per cent. of the land surface is under a rainfall of less than 20 inches; thus necessitating the adoption of dry-farming for the profitable growing of crops. It is estimated that about 10 per cent. more receives a rainfall of from 20 to 30 inches, making dry-farming essential. Thus a total of 65 per cent. is directly concerned in the methods of dry-farming. Only a very small portion of this area can ever be completely reclaimed by irrigation practices, leaving the major part of the world always interested in the movement of dry-farming.

The study of this system becomes even more imperative in countries like India where the rainfall over a portion of the country is not only short but extremely precarious, and when one comes to consider the amount of land in India which would benefit by a knowledge of dry-farming it becomes obvious that it is up to us to lose no opportunity of obtaining information which may assist us.

History, definition, and a few contentions regarding Dry-Farming.

Though America has the privilege of bringing dry-farming in limelight to-day, it is not to be supposed that it is a new system. It is rather a new name to a system which was practised in ancient days. Unmistakable proofs have been found to-day in all the ancient civilizations in China, Mesopotamia, Egypt, Mexico, Peru, etc., testifying that it was a practice in vogue in those days. Kearney[1] in a study of dry-land olive culture in North Africa quotes Tunis as an example of the extent to which it must have been practised in the old days. Though Tunis has a rainfall of only about 9 inches on an average, the ancient ruins are of such a nature that the territory was probably densely populated. No evidence of irrigation practice is found and the inference is that the territory must have been dry-farmed. But, however well known the art may have been in the past, the credit of reviving and awakening a general interest in this almost forgotten and neglected practice must be awarded to those American pioneers who wended their way westward and subdued the desert in their struggle for existence. The curious thing in this connection is that these methods were simultaneously and independently developed in Utah, California, Washington, and the Great Plains. However, to Utah belongs not only the claim of precedence in this respect, but also the credit of being the first to undertake a complete study of the behaviour of soil moisture which has given the system a scientific basis it enjoys to-day, mainly through the researches of Dr. Widtsoe and his colleagues.

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[1] *Bulletin No. 125 of the Bureau of Plant Industry, U. S. Dept. Agri.*

Dr. Widtsoe defines dry-farming as the profitable production of useful crops without irrigation on lands that receive a rainfall of 20 inches or less. In districts of torrential rains, high winds, unfavourable distribution of rainfall or other water dissipating factors, dry-farming is also properly applied to farming without irrigation under annual precipitation of 25 or even 30 inches. A large part of the dry-farm territory in India will fall into the latter category where conditions of water dissipation are far more pronounced in every particular than the worst that could be obtained in the United States.

Even in the United States, however, there is a considerable difference of opinion regarding the best way of applying the principles of dry-farming to soil management. There comes in the wake of every scientific discovery a time when undiscerning and unscrupulous persons make unwarranted generalizations with consequent failures and confusion, and in a country so much given to speculation and exploitation it must have assumed rather serious proportions to compel the Federal Department of Agriculture to caution the uninformed public against some misconceptions which it would be well to quote here

"In conclusion, the following misconceptions concerning dry-farming may be mentioned as among the most serious: (1) That any definite 'system' of dry-farming has been or is likely to be established that will be of general applicability to all or any considerable part of the Great Plains area; (2) that any hard and fast rules can be adopted to govern the methods of tillage or of time and depth of ploughing; (3) that deep tillage invariably and necessarily increases the water-holding capacity of the soil or facilitates root development; (4) that alternate cropping and summer tillage can be relied upon as a safe basis for a permanent agriculture or that it will invariably overcome the effects of severe and long-continued droughts; and (5) that the farmer can be taught by given rules how to operate a dry-land farm."[1] It is well to keep these in mind in India also.

[1] *Year-Book of the United States Department of Agriculture*, 1911, p. 256.

Some noteworthy facts regarding American agriculture.

An agricultural specialist from America, who had been in India as recently as 1914, observed to the writer that the one thing that struck him more than anything else while there was the very poor physical condition of the soil, an observation that is entirely true. By contrast the condition of American soils ready for planting is almost perfect. But this is due more to the suitable climatic conditions by which good physical condition and preparation of the soil can be secured easily and cheaply. Even if the worst came to the worst the soils here over the major part of the continent never dry out or bake so hard that cultivation becomes impossible after the crops have been off the ground for any length of time. As an additional help there are the autumn rains followed by the snow. If conditions do not allow the autumn ploughing of the soil, as the snow thaws in the spring, the soils come in just an ideal condition for preparatory tillage. It is this factor that makes preparatory tillage so easy in America. On the other hand in India where the crops come to maturity, not so much on account of low temperature as is the case here, but due to the sheer lack of water, the roots dry up the soil in such a wholesale fashion that cultivation becomes only possible if attempted below the zone of block formation which is in many cases more than a foot deep, and even after this, the soil never falls into that crumbly condition so essential for good cultivation. Even granting that a deep ploughing is conducive to a better physical condition and a better absorption of water than no ploughing, the only way it could be accomplished is by machine ploughing, which under the present condition of agriculture does not seem easily possible or profitable either. In India we have practically only two sowing seasons: the *kharif* and *rabi*, but these are usually not co-existent, being found in widely separated territories, so that there is but one sowing season in a particular locality and since the farmer is always afraid of a short season the sowing of all crops has to be done post-haste in order that the crops may have a chance to mature. Any one connected with agriculture in India knows how feverishly hurried these operations are. As a contrast,

here in America the farmer is practically farming all the year round, and often starts his crop the year before, as in the case of winter wheat, clover, or sowing in the growing crop in the fall, *viz.*, cowpeas in corn or cotton, etc. Thus he sows his wheat in autumn, it grows a little and rests during the winter under the snow. In spring, when the snow thaws the wheat begins to grow again. In spring, he may sow rye, oats, or barley and seed down the field to clover which may occupy the land from year to year. Different seasons for sowing corn, potatoes, tobacco, clover, wheat and other crops are possible owing to the moisture conditions being such that a great variety of crops could be grown, resulting in the most profitable use of the farmer's time, and in winter, when field operations are at a standstill, he attends to his dairying or stock feeding. Thus conditions are rarely so devoid of the necessity of doing any agricultural work as they are in India with a growing season of only three or four months in each locality, and hard, hot dry weather for the rest of the year preventing crops being taken from season to season under dry-farm conditions.

Other factors are the size of the farms, their contiguity, the presence of the farmer on his estate, the business and competitive condition of farming, the supply of effective machinery, and the large capital available to the farmer for investment. All of these are important, but the peculiarity of the season as explained above, the possibility of distributing crops over a large period and above all the absence of social or religious prejudices such as crop up in every attempt at improvement in India are matters that are not so well realized there and hence are grouped under a separate heading to give them the proper emphasis.

Basis of Dry-Farming.

The theoretical consideration of dry-farming becomes only possible after the water cost of the dry matter is worked out. Extensive researches have been made in this respect by Wollny and Hellriegel in Germany; by Lawes and Gilbert in England; by King and Widtsoe in America and Leather in India. With the exception of Drs. Widtsoe and Leather the rest have obtained

their results under comparatively humid conditions. Making allowance for the excessive use of water used in his work Dr. Widtsoe places the average water cost per pound dry matter at 750 pounds. A dry crop of wheat in India normally yields about 600 pounds of wheat per acre and taking roughly the same weight to represent straw we have a total weight of 1,200 pounds dry matter. The amount of water required for this yield of grain and straw would be 900,000 pounds at the rate of 750 pounds of water to the dry pound. Since one inch per acre is equal to 226,875 pounds the amount of rain actually used by the crop is about 4 inches per acre. There is no doubt that the farmer will be more than satisfied if he can raise 600 pounds of wheat every year with certainty and since the amount actually required represents only from 15 to 20 per cent. of the average rainfall, there is no reason why with better methods of handling the soil than are now in vogue, larger yields could not be secured in normal years or profitable ones in poorer seasons.

It is well known that all the moisture present in the soil is not available to plants. It is only that portion of the soil moisture which can freely move under the force of capillarity that is useful for good plant growth. The point below which the moisture in the soil is not available to crops is designated the wilting co-efficient and the extensive researches of Briggs and Shantz,[1] show that this is a soil constant and bears a constant relation to the hygroscopic co-efficient of the soil and is higher or lower according to the type of soil. Up to a certain percentage beyond this wilting co-efficient even, the water moves with some difficulty and does not replace what is used by the crop as readily. This point, Dr. Widtsoe[2] suggests, should be called Lento-capillarity. In the particular soil he was dealing with he found it to be 12·75 per cent. It is only the difference between this and the field capacity of the soil for holding water that can be safely relied upon for plant growth. The field capacity of the soil does not necessarily come to its maximum capillary capacity owing to the constant pull of gravity. It has been put at 19 per cent. in a clay soil to a depth of 8 feet;

[1] *Bulletin No. 230 of the Bureau of Plant Industry, U. S. Dept. Agri.*

[2] *Bulletin No. 115, Utah Agri. Experiment Station*, p. 230.

18 per cent. for the clay loam; 16 to 17 per cent. for loams and 14 to 14·5 for sandy loams. Considering 7 per cent. as a fair percentage of readily available moisture one acre foot of soil with a weight of 3,500,000 pounds will supply 245,000 pounds of water and a depth of 4 feet of soil would give 980,000 pounds of available water and referring to calculations previously made, a uniform depth of 4 feet of clay loam or loam soil will hold enough moisture to give 600 pounds of wheat per acre. So much, however, depends upon the uniformity of the soil, depth, and its moisture capacity that it is idle to speculate any further until a study of these factors is made actually on the spot and results obtained.

Factors underlying Dry-farming.

The success or failure of dry-farming methods depends on the resultant of the two opposing forces of precipitation and dissipation. Where this margin is large enough for crop production and can be obtained at a reasonable cost, dry-farming will be a success. The system would not be economical though possible where the cost for obtaining this margin will be such as to seriously interfere with the profits. Conservation of moisture at reasonable cost is, therefore, the basis of the system. The positive factors in this retention of moisture are the soil and rainfall and the opposing forces are evaporation, seepage and surface-wash.

Owing to the tropical climate in India over a large part of the year the losses due to evaporation depending upon temperature, sunshine and winds are far more serious than in the cooler climate of the United States. The loss due to seepage is very slight, if any. Owing to the cyclonic and torrential character of the rain, however, our greatest loss in India is in the surface wash, when not only the rain but a considerable proportion of our best soil also is lost with it. There are no figures at hand showing what proportion of rainfall is lost in this way in India but observations made by Briggs and Belz[1] in this country show that as high as 80 per cent. of rainfall of 2·5 inches falling in 4 hours on a nearly level summer fallowed

[1] *Bulletin No. 188 of the Bureau of Plant Industry, U. S. Dept. Agri.*

field was lost by run-off. The only thing that partly compensates for these heavy losses is the comparatively larger rainfall, but whether it is large enough to allow this loss can only be determined by actual tests.

Conditions for water conservation are ideal in Utah where the dissipating forces are comparatively feeble and the character of the precipitation and soil is such as to give maximum efficiency for storing water.

It may be mentioned here that crops in these highly developed dry-farming regions do not depend on one, two or even three feet of soil but search down to a depth of 8 feet or more in the soil in quest of moisture. Not only has moisture percentage been found to have been affected to this depth but wheat roots have actually been traced to a depth of 8 feet. Observations in North Dakota and Nebraska, though different in other respects, show that roots can feed to a depth of 6 feet positively, and possibly at lower depths. It is this deep rooted habit that enables the crop to yield at the rate of 900 pounds of wheat per acre on an average, on a rainfall of less than 15 inches; and crops of 3,000 pounds of wheat to the acre have been raised while 2,400 pounds is not at all unusual.

These factors of the uniformity and depth of the soil which are so essential for success in dry-farming are often lost sight of or not as well emphasized as they ought to be in other parts where attempts at dry-farming are being contemplated.

The subject of soil moisture has nowhere been studied as completely as in Utah and most of the figures reproduced here are therefore drawn from the investigations at the Utah Agricultural Experiment Station.

Professor Chilcott who is in charge of the Office of Dry-land Agriculture of the United States Department of Agriculture divides the dry-farming area in America in two sections—(1) The Great Plains and (2) The Great Basin or Inter-mountain. The Great Plains area lies principally between the eastern slope of the Rocky Mountains and Missouri-Mississippi Valley. It was in this area that the early reverses were experienced and it is this area where a few of the misconceptions quoted above took shape. It is characterized by a scanty winter precipitation, the bulk of the rains coming in May, June, and July.

The Great Basin or Inter-mountain Region lies between the Rockies and the Sierra Nevada Mountains and the precipitation, though usually less in amount, is chiefly received in the winter and spring, leaving the summer rainless. It is in this region that dry-farming was first found successful and subsequently developed to its present magnitude.

Though the moisture study has been made in various parts of the Great Plains and the Inter-mountain Region, the soil study is nowhere as completely done as in Utah. The following table[1] shows the approximate mechanical analysis of the various kinds of soils where dry-farming is successfully practised in this State.

Average mechanical analysis to a depth of 8 feet.

County	Coarse matter	Sand	Clay
Iron County	4·55	31·79	11·91
Juab „	6·07	29·53	15·69
San Juan	0·87	56·46	9·15
Sevier	31·31	55·31	11·84
Tooele	7·28	38·65	12·91
Washington	16·28	53·86	10·16

It will be seen that quite a variety of soils can be utilized under the dry-farming system.

The great uniformity of the soil can be seen from the following table[2] representing a depth of 8 feet.

Juab County Farm.

Size of particles	Soil separate	1	2	3	4	5	6	7	8
	Coarse matter ...	9·59	5·29	8·94	4·43	5·85	2·20	3·64	3·93
	Fine matter ...	9)·41	94·71	91·06	95·57	94·15	97·80	96·36	96·07
0·1—0·32 mm. ...	Medium sand ...	8·93	8·99	8·73	11·36	15·69	8·93	16·28	12·60
0·032—0·1 „ ...	Fine sand ...	20·05	16·48	12·38	18·87	19·48	27·40	25·00	22·52
0·01—0·032 „ ...	Coarse silt ...	21·97	19·75	22·53	19·06	23·88	22·27	21·88	21·91
0·0032—0·01 „ ...	Medium silt .	15·23	16·78	17·53	17·25	15·43	13·51	13·73	17·03
0·001—0·0032 „ ...	Fine silt ...	13·25	14·88	14·47	18·93	8·01	7·11	8·68	9·74
less than 0·001 mm. ...	Fine clay ...	15·73	16·88	18·62	20·68	12·41	10·03	12·18	13·29

Soils in the Great Plains area are more variable in character and depth and where shallow or under-lain by a porous sub-soil, results in the conservation of moisture are discouraging.

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[1] *Bulletin No. 104, Utah Agri. Experiment Station.*

[2] *Bulletin No. 1[illegible], Utah Agri. Experiment Station.*

The limits of soil types in a section of the Great Plains[1] area are as follows :—

Size of particles	Soil separate	1	2	3
1 mm. and above ...	Fine gravel	...	...	...
0·5—1 mm.	Coarse sand ...	0·1-0·4	0-0·2	0-0·1
0·25—0·5 ,, ...	Medium sand ...	trace-0·3	0-0·3	0-0·1
0·1—0·25 ,, ...	Fine sand ...	1·5-14·1	1·4-12·3	1·6-9·2
0·05—0·1 ,, ...	Very fine sand...	43·1-52·5	37·8-55·4	42·7-58·2
0·005—·05 ,, ...	Silt	36·1-43·6	32·5-42·7	30·4-45·8
less than 0·005 mm.	Clay ...	5·8-10·5	6·7-11·7	8·1-13·3

The importance of having uniform and deep soils can hardly be over-estimated when it is realized that it is the depth which has made the growth of remunerative crops possible ; by the deep roots they send out in search of moisture. That the storage of moisture affects to a depth of 8 feet at least and possibly further can be seen from the table[2] reproduced below.

All moisture percentage on the basis of dry soil.

Season (after)	Date	1	2	3	4	5	6	7	8	Average
Harvest	Sept. 8, 1902 ...	6·37	7·32	8·17	8·55	8·26	9·29	10·10	10·38	8·56
Storage	Apr. 24, 1903 ...	19·29	19·08	18·83	16·99	13·61	12·62	12·24	12·37	15·63
	Increase ...	12·92	11·76	10·66	8·44	5·35	3·33	2·14	1·99	7·07
Harvest	Aug. 24, 1906 ...	8·33	7·63	8·42	9·66	11·30	10·75	9·59	7·93	9·20
Storage	May 11, 1907 ...	18·17	16·73	17·96	16·88	16·59	16·25	14·98	13·48	16·38
	Increase ...	9·84	9·10	9·54	7·22	5·29	5·50	5·39	5·55	7·18

It has been estimated that on an average more than 60 per cent. of the precipitation could be stored in the soil to a depth of 8 feet in Utah. Burr[3] working on the Western Nebraska soil in the Great Plains area has found that, if properly cared for, the summer-tilled or summer-fallow soils showed from 5 to 7 inches more water in the first 6 feet of the soil than similar land growing a crop and the water so stored has been equal to from 40 to 50 per cent. of the rainfall for the same period. Further that the moisture content of the summer-tilled land increases below the 6 feet area and is apparent to a depth of at least 10 feet.

[1] *Bulletin No. 114, Nebraska Experiment Station.*

[2] Widtsoe, *Dry-Farming*, p. 114.

[3] *Bulletin No. 114, Nebraska Experiment Station*, p. 51.

It is a general impression that soils to be retentive of moisture must be either clayey, clay loams or at least silty loams. That such is not however the case, in fact, a lighter kind of soil is more amenable to dry-farming, is the observation of many.

Professor J. W. Powell in his book " Arid Lands " states that a sandy soil seems to be an essential condition for dry-farming.

Recently Clothier[1] working in Arizona found that "The lighter types of soil have proved to be more valuable for dry-farming than the heavier ones."

That sandy soils are not debarred from dry-farming methods can be seen from actual determinations of soil moisture presented in the following table[2] :—

Proportion of rainfall stored in the soil.

Soil Type	Percentage of water in soil in autumn (after harvest) depth of 8 feet	Rainfall during the period of conservation in inches	Percentage of precipitation found in the spring to a depth of 8 feet
Sandy loam	8·78	8·51	87·59
" "	7·87	7·94	95·56
" " ...	8·83	12·14	82·61
" " ...	9·10	16·17	62·77
" " ...	11·03	6·38	67·55
Clay	12·34	10·51	93·17
Sand ..	7·73	7·27	64·80
Loam	11·04	10·65	81·13

The observation that lighter types of soil are more suitable to dry-farming is possibly due to the fact that the heavier soils though they have a large moisture percentage, actually allow a smaller supply to the feeding roots, owing to the wilting co-efficient being higher in the heavier soils than the lighter ones.

Burr working with the Western Nebraska soils has found that water above 7 per cent. of the soil only is available to crops. Taking 17 per cent. as the field capacity of the soil, the portion available would be 10 per cent. (17 – 7 per cent.).

The wilting co-efficient of a clay will be somewhere about 11 per cent. and taking its field capacity at 19 per cent. there will

[1] *Bulletin No. 70, Arizona Agri. Experiment Station*, p. 797.
[2] Widtsoe. *Dry Farming*, p 121.

be left only 8 per cent. as available moisture. Add to this the effect of the lento-capillary water, the ease with which the roots can penetrate the lighter soils and one can see the reason of the observation under consideration.

So far as the chemical composition is concerned the soils appear to be richer in phosphorus and organic matter. In the following table[1] are given the limits of the percentages in the various dry-farming sections in Utah as compared to a few from India :—

Results expressed as percentage in dry soil.

Ingredient	1st foot	4th foot	9th foot	India[2]
Insoluble residue	52·14—88·25	52·38—78·29	46·47—86·87	65·16—88·08
Potash K_2O	0·55— 1·31	0·45— 0·80	0·42— 0·70	0·14— 1·14
Soda Na_2O	0·14— 0·44	0·30— 0·52	0·42— 0·70	0·01— 1·30
Lime CaO	0·56—18·97	3·21—17·83	0·79—20·22	0·13— 3·43
Magnesia MgO	9·42— 2·24	0·59— 2·66	0·75— 2·93	0·22— 2·47
Sulphuric acid SO_3	0·05— 0·13	0·05— 0·17	0·07— 0·11	not determined
Oxide of Iron Fe_2O_3	2·80— 5·42	2·26— 5·23	2·36— 3·02	2·46— 9·27
Alumina Al_2O_3	2·29— 6·33	0·14— 6·47	3·36— 6·62	1·74—13·76
Phosphorus P_2O_5	0·23— 0·419	0·12— 0·356	0·10— 0·264	0·00— 0·23
Carbon dioxide CO_2	0·21—18·55	2·04—15·12	0·14—20·08	0·11— 1·88
Volatile matter ...	3·02— 5·31	2·79— 4·42	1·62— 2·93	0·24— 6·58
Humus	1·09— 1·63	0·50— 1·69	1·15— 1·35	not determined
Nitrogen	0·057—0·116	0·037—0·1	0·018—0·05	0·015—0·24
Total P.	0·191	0·181	0·112	not determined
Total K.	2·32	1·48	1·30	......

A. *Rainfall and its conservation.*

In spite of the lower amount of total precipitation, mention has already been made that dry-farming in the Great Basin has proved more successful than the Great Plains area. This is due to the character of the rainfall, more than 80 per cent. of the rainfall in the Great Basin being received as winter and spring rains while more than 60 per cent. in the Great Plains falls after the crops have been sown and over 30 per cent. in summer. The following table shows the average seasonal distribution of rainfall in the two regions :—

Region	Rainfall	Percentage in fall after harvest	Percentage in winter mostly snow	Percentage in spring	Percentage in summer
Great Basin ...	14·53—19·07	16	23	42	19
Great Plains ...	11·92—21·30	12	9	43	36

[1] *Bulletin No. 1[illegible], Utah Agri. Experiment Station.*

[2] Hilgard. *Soils*, 1912, p. 412

It will be seen that the Great Basin receives 23 per cent. of its precipitation as snow against only 9 per cent. in the Great Plains and it is doubtful if there could be a more ideal condition of storing water if the land is well prepared than the snow, which, as it melts in the spring, gradually seeps through in the soil deep down with no run-off, evaporation, or seepage to speak of. The rainless summer prevents any tendency on the part of the crop to develop surface feeding roots and the plant thus uninterruptedly follows the moisture deep down into the soil.

As regards summer rains, the factors of dissipation in the form of run-off and evaporation are most active at the time the rains come. Besides, while a rainfall sometimes may help to pile the annual average it may not be of any use in increasing the soil moisture—a condition to which we in India are well accustomed. Briggs and Belz have observed that a monthly precipitation of 1·9 inches coming in nine light showers was of no practical value, as it all evaporated before penetrating the surface mulch. It has been repeatedly[1] observed that even a rainfall of half an inch does not add to the moisture supply unless followed by others within ten days. As a compensating circumstance, however, of light summer showers, is the fact that a rainfall of from quarter to half an inch may have a decidedly beneficial effect on the crop, though it again becomes a double-edged sword, since it tends to encourage surface roots and in the case of long dry periods specially at a critical period when water is being fast used by the crop, the crops would not have enough time to send down deeper roots and may receive as a result a serious check or possibly end in failure.

It appears that in the long run it would be better if such light showers were prevented from having any effect on the crops in encouraging surface rooting, by deep intertillage, and though it might result in a temporary check to plant growth, the ultimate safety of the crop could be more safely assured in case of the long dry periods, which are only too prone to occur in India at some stage of the crop.

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[1] *Bulletin No. 70, Arizona Agricultural Experiment Station*, p. 738.
Bulletin No. 114, Nebraska Experiment Station, p 51

Dr. Widtsoe in summing up the subject says : " A great deal has been said and written about the danger of deep cultivation because it tends to injure the roots that feed near the surface . . . True, deep cultivation when performed near the plant or tree, destroys the surface feeding roots, but this only tends to compel the deeper lying roots to make better use of the sub-soil. When, as in arid regions, the sub-soil is fertile and furnishes a sufficient amount of water, destroying the surface roots is no handicap whatever. On the contrary in times of drought the deep lying roots feed and drink at their leisure far from the hot sun and withering winds and the plants survive and arrive at rich maturity while the plants with shallow roots wither and die or are so seriously injured as to produce an inferior crop.

" One of the chief attempts of the dry-farmer must be to see that plants root deeply. This can be done only by preparing the right kind of seed-bed and by having the soil in its lower depths well stored with moisture, so that the plants may be encouraged to descend. For that reason an excess of moisture in the upper soil when the young plants are rooting is really an injury to them."

B. Absorption and retention of moisture.

Deep ploughing with subsequent tillage and in parts where the rainfall is below 12 inches, summer fallowing to carry over the supply of moisture from one to the other season are the two principal means used for storing water. Nearly all the contradictions with regard to the dry-farming system that have arisen are with regard to these two factors—deep ploughing and summer tillage.

The following presents the view of Professor Chilcott[1] of the United States Department of Agriculture with regard to deep ploughing. " Perhaps one of the most common fallacies is that deep ploughing invariably and necessarily increases the water-holding capacity of the soil Our investigations show that in many instances the receptivity of the soil is governed entirely by the physical condition of the upper 4 or 5 inches, the undisturbed sub-soil being

[1] *Year-Book of the United States Department of Agriculture*, 1911, p. 254.

of such a nature over very considerable portions of the Great Plains that it is able to transport downward by capillarity all the moisture absorbed by the surface layer of soil as rapidly as it is accumulated in that layer. Under such circumstances there would manifestly be no increase in either the receptivity or water-holding capacity of the soil if the ploughing were deeper than 4 or 5 inches. Whether this rule will apply to any given soil can be determined only by careful observation, which should extend over a sufficient period of time to include a considerable range of climatic conditions and particularly the varying degrees of intensity and duration of rainfall." Another group of investigators[1] state: "The advocates of deep tillage and ploughing to the depth of a foot to sixteen inches argue that the deep stirring and loosening of the soil creates a greater ability to store water. At none of the Stations in the Great Plains have these claims been justified by the results of experiments."

We have at present in India a wave of deep-ploughing sentiment and the above will certainly afford food for a good deal of reflection and investigation in that connection.

Another interesting and rather unusual statement[2] from one of the experimental stations of the Great Plains area is as follows:— "Advocates of dry-farming systems based on the 'dust blanket' theory strive by maintaining a soil mulch to reduce the loss by evaporation. They reason that by stirring the surface, capillarity will cease to act in bringing up water from the lower depths to the surface. But they fail to take into consideration that because of the absence of a free water table capillarity as a force for moving water upwards ceases and is of no practical importance.[3] The apparent benefits as measured by increased moisture content attributed to the soil mulch, have more than likely been due to the fact that in maintaining the soil mulch, loss of water has been prevented

[1] *Bulletin No. 110, North Dakota Experiment Station*, p. 172.

[2] *Ibid* p. 174.

[3] This statement is not supported by experimental evidence included in this publication: but there is abundant proof of it in data of the Office of Dry Land Agriculture, a part of which has been published by W. W. Burr of that office, in *Research Bulletin No. 5, University of Nebraska*, pp. 75-77.

by the eradication of the greatest dissipators of soil moisture—namely, *weeds*. From the standpoint of moisture conservation cultivation is beneficial when weeds are destroyed or prevented from growing. This fact should not be taken to mean that less cultivation is necessary but rather that such operations should be performed at times when weeds can be combated. If the soil checks and cracks deeply, air is allowed to circulate below the normal drying depth of the surface and cultivation then is necessary. **Otherwise the soil mulch can be disregarded.**" (The heavy type are ours.)

However that may be in other sections, the writer in his visits to the fields in Utah was indeed amazed to find that within 3 to 4 inches of the surface mulch, under a continuous, hard, hot sun, with neither rain nor dew, the soil should be found to be ideally moist for crop growth and that it should be in this condition to a depth of 6 or 8 feet. If the writer had not personally seen this, it would have been difficult of belief, so incompatible appear the dry, hot surface mulch at the top and the cool moist soil below.

Even in the Great Basin region, however, ploughing deeper than 7 to 8 inches has not had any marked effect on the yield or the water stored. In fact as a result of five years' experiments at the Nephi Sub-Station,[1] Utah, no material difference was observed in the yields obtained from the plots ploughed at different depths varying from 5 to 18 inches.

Indeed in the light of these findings, the question of deep ploughing in India deserves more than a casual and theoretical consideration. It may turn out after all that what we want most is deep intertillage rather than deep ploughing.

Speaking of the soil mulch Professor Farrell[2] has drawn attention to the fact that two factors enter in the formation of soil mulch—receptive and retentive. He has shown how in parts where wet and dry periods alternate in rapid succession, the receptive

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[1] *Bulletin No. 157. U. S. Dept. Agri. Contribution from Bureau of Plant Industry*, p. 44.

[2] *Dry-Farming*, vol. V, no. 2, p. 245. *The Annual Hand-book of Dry-Farming, 6th International Dry-Farming Congress.*

and the retentive condition of the soil mulch oppose each other. Thus the 'dust mulch' so much advocated by authors in dry-farming becomes actually a hindrance in the effective reception of the precipitation specially in heavier soils, because the fine dust mulch under a heavy rain, runs together and interferes with penetration and occasions an excessive loss by run-off. The run-off in such cases may actually exceed that from a soil which has no mulch at all. Reference has already been made to the observation that 80 per cent. of the rain was lost by surface washing in a heavy rain on a level summer fallow while under the same conditions it was observed that only 40 per cent. was lost on an adjacent stubble field.

In considering the soil mulch therefore in parts where dry and wet periods alternate as in India, both the receptivity and the retentivity of the soil condition should be borne in mind. As a result, in heavy soils it will be safer to leave the surface relatively coarse and lumpy to reduce the tendency for running together and causing a loss by run-off.

Discussions with regard to the value of a summer fallow run quite as hot as on the value of deep ploughing. Thus, results obtained in North Dakota show that while stored water may be of value in supplementing rainfall, it is unable in itself to mature a crop in Western North Dakota; but even here it is admitted that summer tillage has a certain value as insurance against crop failure. Others[1] find it too extravagant a system. Clothier[2] states that summer fallowing by the ordinary methods has not been successful in permanently accumulating water in the soil even after a two-year fallow in Arizona.

It must not be forgotten in this connection that those who advocate summer fallowing do it for a certain set of conditions:—(1) Where the annual rainfall is too small to produce a crop every year, (2) under particular conditions of depth and uniformity of the soil. That such is the case is proved by hundreds of moisture determinations and crop results in the Great Basin. Even here

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[1] *Year-Book of the U. S. Dept. of Agri.* 1911, p. 253.
[2] *Bulletin No. 70, Arizona Experiment Station*, p. 797.

when conditions of soil or rainfall are better, the summer fallow is practised only once in three years. In other places once in four years is found enough. In Kansas it is customary to do so only once in six years.

A modification of summer fallow, which owing to the poor humus content in Indian soils is likely to prove very useful, is the turning under of a green crop in the fallow year. This will not only improve the physical condition of the soil, the chemico-bacterial activities and the consequent liberation of plant food; but will also add to its water-holding capacity on account of the added humus. Experiments so far, however, tend to show that in India it does not pay to turn under huge quantities of green matter unless there is enough water available for complete decomposition of this material and its assimilation by the soil. The aim should be to turn under only as much as would be properly decomposed and assimilated. Even if it is only a slight growth that is ploughed under, it would do more good than a huge mass of loose decomposing matter intercepting the continuity of the soil and upsetting all its useful physical functions.

Choice of crops, Rotations, and Machinery.

Choice of crops. The limited amount of available water naturally requires the growth of only drought-resistant crops. Kearney and Shantz[1] describe drought-resistant plants as having the ability either to endure, to evade or to escape drought so as to produce successful crop growth. Ability to endure a drought may be due to the storage of water in the plant body or ability to become dormant. Of the cultivators' crops, the tendency to become partly dormant is shown by alfalfa and *sorghums.*

The evading of drought can be accomplished by control of transpiration or exceptional root development. Alfalfa with its deep tap root illustrates this point among the cultivated crops.

The adaptation for escaping the drought is illustrated by plants that require a very short growing period before the season of drought begins, such as the early varieties of small grains.

[1] *Year-Book of the U. S. Dept. of Agri.* 1911, p. 352.

However, the crop plants to succeed under dry-farming conditions must possess more than one of the adaptations above mentioned. Thus alfalfa has not only the ability of becoming partly dormant under adverse conditions but can also partly evade drought on account of its deeply penetrating roots. The early varieties of successful small grains have not only a shorter growing season but also are characterized by a small total leaf surface reducing transpiration. The authors mentioned above found that *sorghums* afford the best example among crop plants of a combination of adaptations for meeting drought. They are specially drought evading, and also have considerable power of endurance. In seasons when the rainfall is normal as to total quantity but very irregular in its distribution, while crops like alfalfa and *sorghums* may finally give good yields, corn and potatoes for example which have less ability to become dormant may utterly fail. Thin planting, clean cultivation, cutting and pruning and growing dwarf varieties are other means of evading a drought.

The ultimate object of farming being profitable crop production, such crops must only be grown as are reasonably secured from destruction by drought and which also when grown under the conditions of moisture supply normal to the region, can give a product that will be remunerative to the grower.

It is owing to this factor of profits that wheat is the principal dry-farm crop. Winter wheats wherever possible always give better returns. Of the spring wheats the Durums have become the most popular. In the southern section of the Great Plains Region *sorghum* is found to be the most remunerative and is already a staple crop in parts of Texas, Oaklahoma, Kansas, and New Mexico.

Alfalfa ought to prove a very useful rotation crop in dry-farm regions provided it is not too thickly sown, about 5 to 6 lb. being enough. As a rule dry-farm alfalfa yields well as a seed crop, though, if properly cared for, good hay can also be obtained. *Sorghum* is the third principal dry crop and is likely to extend in cultivation. Other crops like barley, oats, corn, are sometimes used in rotation with wheat in some parts especially in the northern Great Plains area.

A fact that was once overlooked and led to disastrous results is the thin rate of seeding to be used. A thickly sown field may look better at the start but it so depletes the moisture-supply in the soil in the preliminary stage of leaf and stalk formation that very little is left for use at the critical time of forming the grain. Thin seeding is, therefore, a very essential factor in successful crop production under dry-farming. 25 to 30 pounds of wheat seed is used to the acre in the Great Basin.

Rotation. No rotation practically exists where summer fallow is practised every year. In some others where the land is fallow once in three years wheat after the fallow and spring barley following the wheat is taken. In some cases when the soil has run down, it is put down to alfalfa for three or four years before growing wheat again.

Machinery. An average holding to make farming pay is supposed to be 160 acres with half the area in fallow every year. In addition to the necessary wagons and hand tools and four horses the following complement of machinery is recommended—a plough, disc harrow, smoothing harrow, drill seeder, harvester or header and mowing machine.

Threshing is always done on contract by travelling tackles.

Power farming is practised on a few unusually large estates, but has not yet become a general feature like power threshing.

One thing more than another which has made dry-farming profitable is the effective machinery which has enabled the farmers to cultivate and farm their lands cheaply. In Dr. Widtsoe's opinion, dry-farming more than any other system of agriculture is dependent for its success upon the use of proper implements of tillage and that if it were not for the invention of labour-saving machinery, it is doubtful whether the reclamation of the great arid and semi-arid regions would ever have been possible. The future as well as the past of dry-farming is thus intimately connected with the improvements already made and to come in farm machinery.

A review of conditions in India.

Such being the factors that control success in dry-farming in America the next point is to consider how we stand in these respects in India. If land is to be prepared efficiently so as to receive and retain the rainfall effectively, costly machinery must be used. In most cases, for the present it is beyond the means of ordinary farmers to own these machines for themselves. The only way, therefore, is to use them co-operatively and the great strides that this movement is making at the present ought to make such a co-operative preparation of the soil possible where it is proved by experiment that dry-farming can be profitably pursued.

Conditions of rainfall in India are similar to those of the Great Plains region of the dry-farm section in America. Professor Chilcott describing the variableness of the season in this section says, "Within the area specified, annual precipitation at a given station may easily range during a term of years from as low as ten to as high as thirty inches. It is not an unusual occurrence to have a single torrential downpour of rain which exceeds in amount the normal precipitation for the month in which it occurs. These torrential rains frequently come with such force as to puddle the soil surface, thus making it impervious to water and resulting in the utilization of but a small percentage of the precipitation."

If one had started describing the uncertainty and variableness of rainfall in India, the description would tally word for word, with the difference that every factor mentioned is far more pronounced in India. As every one knows it is the uncertainty and variableness of the rainfall that upsets farming in India and not the smaller amount. Our similarity to the Great Plain region does not consist only in the variableness of the season but also in the fact that all our rain is received while the crops are growing, delivered in about 4 months period technically, but really in not a few days but only a few hours. Our problem thus is unquestionably more difficult to meet, not because of this fact alone, but also because the dissipating forces are very strong. The only thing that serves as a partial off-set is the large amount of our average annual rainfall and possibly our deep soils where such exist in districts of large rainfall.

While discussing the influence of soil in dry-farming, attention has already been drawn to the fact that it is a misunderstanding to suppose that only clayey soils are adapted to dry-farming. In fact as explained above loams and lighter types of soils are even preferred, where they are uniform to a depth of 8 feet or more. In fact this uniformity of character is the corner stone of the dry-farming system. It is this uniformity unhampered by hard-pan or gravel seam or a murum layer or clayey sub-soil or sticky shale, that gives free scope of movement to the water from one depth to the other. The force of capillarity is uniform throughout; there is no hard-pan to limit the soil's storing capacity nor a pervious layer to drain off the much needed water down below beyond recovery when needed by the crop, owing to the feeble lifting power of the intervening pervious layer.

The water in such uniform soils simply travels up and down under the influence of capillarity and gravity, but never goes so deep as to be beyond the reach of plant roots. Such deep soils are not infrequent in India and must prove of great value.

It goes without saying that the yields under dry-farming methods are bound to be smaller than in others, and that a kind of insurance must always be paid in the higher cost of using dry-farming methods entailing greater cost of crop production. But dry-farming has succeeded best where a drought is anticipated every year and provision made to fight it. It will never be a success so long as the farmer indulges in the costly temptation of the higher and cheaper but uncertain yields over the admittedly smaller and costlier but certain yields under the dry-farming system.

On theoretical considerations it seems possible that such a certainty of yields can be obtained over quite a large area if dry-farming methods are carefully followed. Experiments on the spot must prove that such is the case.

When found successful, it will practically do away with the crowding in of all agricultural operations in a very small period of the year, leaving the rest unoccupied. It will make farming more evenly distributed and will consequently put a value on the now idle labour of the farmer and will give a certainty to his vocation

It is not a problem that can be solved in one or two years' time, neither is it one that can be successfully met by one cut and dried method. Different soils and climatic conditions will respond to different treatments, and consideration must be given to all these factors. In some, fallowing might be found necessary in a cycle of three or four years. In others it might become necessary every other year. In some cases fallowing with green manuring will have better effect. Some crops might do better in one section and others in others. Fortunately there is no lack of dry-farm crops or varieties in India. Consciously or unconsciously we have been dry-farming most of the time in certain districts. What is wanted is the building up of these crops to constitute a pure strain. Wheat, *juar*, cotton, lucerne, gram, linseed, all will find a place in our system. The point is to experimentally prove what is the best system for given conditions of soil and climate. If there are any means by which something definite can be evolved out of the fickle Indian monsoon they are likely to be the rigorous adaptations of dry-farming principles.

It is a problem that is ever present before the agricultural investigator, the Government and the cultivator, year in and year out. When all the countries in the world—America, Canada, Mexico, Brazil, Australia, Africa, Russia, Turkey, Palestine and even China—have lined up and gone ahead in dry-farming investigations, is it fit that we in India, who would perhaps benefit most from such an investigation, should not be in the forefront ?

ON THE MODE OF INFECTION AND PREVENTION OF THE SMUT DISEASE OF SUGARCANE.

BY

S. L. AJREKAR, B.A. (Bom. & Cantab.),
Assistant Professor of Mycology, Agricultural College, Poona.

THE smut disease of sugarcane is caused by the fungus *Ustilago Sacchari Rabenh.* and is easily recognized by the characteristic long whip-like sooty black shoot, devoid of leaves, produced from the top of the affected plant. This is often several feet in length and much curved on itself. In its earlier stages it is covered by a thin silver-white sheath, which later on ruptures and exposes a sooty black dust which consists of the spores of the fungus.

As a rule only the thin varieties like Sanna-bile and Ashy Mauritius[1] are attacked. The thick varieties—Pundya and Red Mauritius, for example—cannot, however, be regarded as altogether immune, as they unmistakably showed the disease on the Manjri Farm during the last two or three years.

Dr. E. J. Butler,[2] in his paper on the "Fungus Diseases of Sugarcane in Bengal," suggested the possibility "that the smut disease can be transmitted both through the infected sets cut from diseased plants which contain living mycelium and also through spores." The same author states further that "experiments in treating this smut are still to be carried out.....Whether it is possible by pickling the sets in copper sulphate or some of the other methods which have proved efficacious against grain smuts, to prevent spore-infection of sound sets remains to be seen."

[1] Ashy Mauritius is originally a thick variety, but on the Manjri Farm it looks more like a thin variety than a thick one.

[2] Butler, E. J. *Mem., Dept. of Agri. in India, Bot. Ser.*, vol. I, no. 3, 1906.

The experiments described here were suggested by these remarks of Dr. Butler. The object in view was to ascertain how infection usually took place in the field in the case of smut in sugarcane and to test the efficacy of treatment of sets with copper sulphate previous to planting.

The experiments recorded below were carried out during the last three years on the Government Sugarcane Experimentel Station at Manjri near Poona, where smut has been appearing sporadically year after year, particularly on some of the thin varieties. The writer is indebted to Mr. Mahajan, Superintendent of Manjri farm and to Messrs. Padhye and Sane, Graduate Assistants on the same farm, for looking after the experimental plots and much help during the progress of the experiments.

Experiment No. 1.

1912–1913.

Method. Careful search was made for stools entirely free from smut in the Ashy Mauritius plot and sixty sets fit for planting were selected from these. Another lot of sixty sets was cut from canes which had distinctly shown the smut. The healthy and diseased sets were further divided into two lots of thirty sets each and one half were steeped in copper sulphate solution of 2 per cent. strength for fifteen minutes and the other half was left untreated. The sets were then planted in four plots as follows:—

Plot No. I	...	Diseased sets 30, steeped.
Plot No. II	...	Diseased sets 30, unsteeped.
Plot No. III	...	Healthy sets 30, steeped.
Plot No. IV	...	Healthy sets 30, unsteeped.

The sets were planted on the 13th of Decembar 1912. The plots were chosen in a part of the farm far removed from any standing sugarcane. The soil was virgin soil[1] broken up for the first time for this experiment.

Observations. The germination was uniform in all the plots except No. IV, where only a few shoots came up.

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[1] This remark does not hold good for the other experiments that follow.

The first case of smut observed was on 13th March 1913 and it occurred in plot No. I.

In May 1913, smut was found in all the plots except in No. III.

No. III remained smut-free till November 1913, when three smutted shoots were observed in it.

It was not possible to make an exact count of the smutted shoots in all the plots, yet it was observed that No. II suffered the most and No. III remained smut-free the longest and suffered the least.

Remarks. The results of the experiment pointed to the following conclusions :—

(1) Infection may be carried in diseased sets, as indicated by the behaviour of plot No. I.

(2) Steeping sets in copper sulphate solution is not, by itself, sufficient to prevent smut; indicated by the plots Nos. I and III.

The appearance of smut in plot No. IV which had sets from healthy canes in it may be due either to infection by spores adherent to the sets or dormant mycelium in the sets resulting from direct aerial infection by wind-borne spores on parent canes, though the latter showed no external signs of it.

Experiment No. 2.

1914-1915.

The experiment of 1913-1914 was repeated, using a hundred sets to each of the four plots as in the following table :

Plot No.	Treatment	Date of planting	Germination on 1-4-14	First appearance of smut on	No. of smutted shoots on 13-2-15
I	Healthy sets, steeped in copper sulphate 2 per cent. strength for fifteen minutes.	27-2-14	17 shoots	21-5-14	3
II	Healthy sets, unsteeped ..	27-2-14	159 ,,	29-5-14	122
III	Diseased sets, steeped as above	27-2-14	2 ,,	21-5-14	2
IV	Diseased sets, unsteeped ...	27-2-14	109 ,,	21-5-14	228

Remarks. Steeping was found to retard germination seriously and had no effect in preventing smut. A regular count of the number of healthy shoots at the end of the experiment was found impracticable in this as in the other experiments recorded here owing to excessive tillering; hence the proportion of smutted to healthy shoots could not be ascertained. Yet the figures for smutted shoots give a clear indication that smut appears to the greatest extent in those plots which had sets from diseased canes planted in them. It has to be remembered in interpreting these figures that the germination in the plots Nos. II and IV was much better than that in the corresponding plots Nos. I and III. When corresponding plots only are compared, the infective power of diseased sets becomes quite apparent. The appearance of smut in plots with healthy sets in them again suggests infection by spores adherent to the sets or by dormant mycelium in apparently healthy canes resulting from direct aerial spore-infection.

EXPERIMENT No. 3.

1915–1916.

The experiment of 1913-1914 was repeated using a hundred eyes for each plot and using two strengths of copper sulphate for steeping. There were, therefore, six plots in this experiment as under :—

Plot No.	Treatment	Date of planting	Germination on 13-3-15	First appearance of smut on	No. of smutted shoots on		TOTAL
					31-8-15	12-2-16	
I	Healthy sets, steeped in 2 per cent. $CuSO_4$.	13-2-15	7 shoots	?	Nil	5	5
II	Healthy sets, steeped in 1 per cent. $CuSO_4$.	13-2-15	14 ,,	19-5-15	,,	Nil	0
III	Healthy sets, unsteeped ..	13-2-15	48 ,,	19-5-15	1	3	1
IV	Diseased sets, steeped in 2 per cent. $CuSO_4$.	13-2-15	3 ,,	21-4-15	1	0	1
V	Diseased sets, steeped in 1 per cent. $CuSO_4$.	13-2-15	3 ,,	15-4-15	6	121	127
VI	Diseased sets, unsteeped .	13-2-15	13 ,,	1-4-15	15	77	92

Remarks. These results confirm generally those of the two previous experiments. They indicate that the disease is most surely conveyed through the use of diseased sets. Steeping is again seen to be ineffective in checking smut and moreover affects germination seriously. Only three of the diseased sets treated with 2 per cent. copper sulphate solution came up and one of them showed the disease. Plot No. III with healthy sets in it has practically remained healthy without steeping.

Experiment No. 4.

1915–1916.

Objects. To determine if smut spores adhering to the surface of sets are able to carry the disease and also to observe the effect of copper sulphate solution on adherent spores.

Method. Smut spores were smeared on to the surface of 25 sets planted in each of the three lines labelled II, III and IV. Sets for Nos. II and III were steeped in 1 per cent. copper sulphate solution for ten minutes. No. 1 was left untreated in any way as a control. All sets were selected from smut-free canes (Sanna-bile variety).

Plot No.	Treatment	Date of planting	Germination on 8-4-15	First appearance of smut on	No. of smutted shoots on		Total
					31-8-15	12-2-16	
I	Control	13-3-15	53 shoots	2-6-15	1	1	2
II	Covered with spores; steeped.	13-3-15	28 ,,	12-6-15	1	25	26
III	Ditto	13-3-15	37 ,,	16-6-15	5	ver 500	Over 500
IV	Covered with spores; unsteeped.	13-3-15	58 ,,	16-6-15	1	Practically every shoot was smutted	

Remarks. There was no indication in the earlier stages of the experiment that adherent spores carry on the disease but towards the end[1] the infective power of adherent spores was quite clearly shown, practically every shoot showing the disease in plots III and IV and many in plot II. Steeping is again seen

[1] This result is in agreement with that obtained in Java as quoted by Dr. Butler (*loc. cit.*).

to have no value in the treatment of sugarcane smut, especially as it has again affected the germination of the eyes. The use of sets from healthy canes in the control plot gave a crop practically free from disease without steeping.

Experiment No. 5.

1914.

This was designed to verify the deleterious effects of the copper sulphate treatment on the germination of sugarcane sets indicated in the other experiments.

Method. Sugarcane sets were steeped for different lengths of time and in different strengths of copper sulphate solutions (2 per cent. for 30 and 10 minutes; and 1 per cent. for 30 and 10 minutes). Sets with 100 eyes counted were used for each item and were planted on 22nd August 1914.

Observations on 16th September 1914 :—

Treatment	Number of shoots come up
2 % for 30 minutes	0
2 % " 10 "	1
1 % " 30 "	4
1 % " 10 "	9
Control—unsteeped	26

Remarks. Here, again, the deleterious effect of steeping is noticeable, though the germination even in the control plot was rather poor.

Experiment No. 6.

1915.

This was carried out in the Seed-testing Laboratory at the Poona Agricultural College, to place beyond doubt the result of Experiment No. 5.

Method. Sets having 20 "eyes" in all were steeped in a solution of copper sulphate of 1 per cent. strength for ten minutes and another lot having 12 "eyes" on them were left untreated as control. These were germinated on moist sand. The experiment was started on 15th March 1915.

Results on the 26th March 1915 :—

1. Untreated ... All buds germinated; shoots vigorous, about eight inches, vigorous growth of adventitious roots.
2. Treated ... Only three buds showing some life; hardly any root growth.

A photograph of this experiment taken on the 27th March is given opposite (Plate XX).

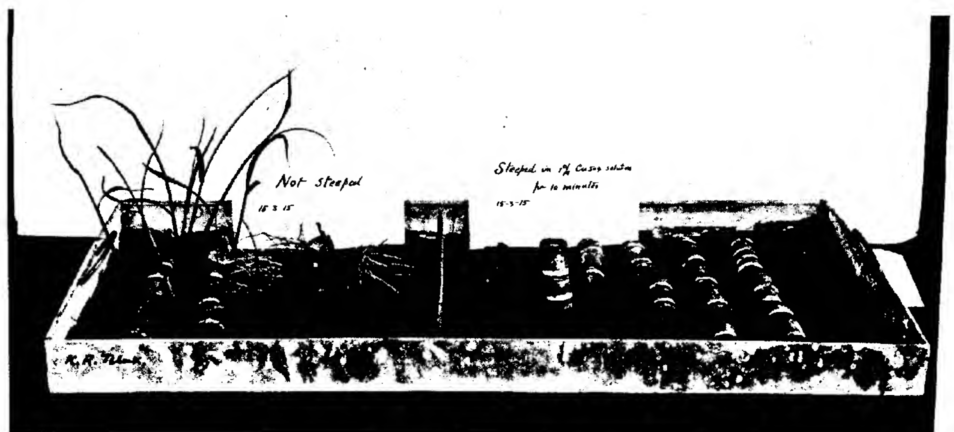
Remarks. This experiment leaves no doubt as to the injurious effect on sugarcane sets of steeping in copper sulphate solution.

General conclusions.

The above experiments indicate clearly that the surest way of getting smut in a crop of sugarcane is by the use of sets from diseased canes. The cultivators, as a rule, do avoid obviously diseased canes for planting purposes and this explains probably why the disease has existed so far only in the sporadic stage. As an additional precaution, however, it may be suggested that not only obviously diseased canes but also the whole of the stools which show the disease on one or more shoots should be avoided for seed purposes, as they are likely to contain the fungus though there may be no external signs of it.

That the source of infection when diseased sets are used for planting is the mycelium of the fungus in the tissues of the sets is indicated by the evidence obtained by microscopic examination of the tissues of affected canes. Even in hand sections, the mycelium of the fungus has been clearly made out in the sixth node behind the apex and it is possible it could be made out still further below by more elaborate histological methods. That the fungus can get into the buds and side shoots of an affected cane is also shown by the fact that side shoots of not more than six inches in length from quite near the base of an affected cane already show smut occasionally and further by the fact that microscopic examination in a few cases revealed the presence of the fungus in the tissues of the dormant buds of an affected cane.

Smut generally appears early in the life of the crop, in three to five months from the planting, when the source of infection is diseased sets.



Effect of steeping in copper sulphate solution on germination of sugarcane sets.
(Photograph taken on 27-3-15.)

Infection by spores adhering to sets takes place, but the attack in this case does not become obvious till the crop approaches maturity.

Aerial infection of shoots by spores and the formation of a dormant mycelium in them is probable, though the above experiments give no direct proof of this. Infection by spores lying in the soil also possibly occurs. But these questions can only be settled by further study.

Steeping in copper sulphate solutions is useless and worse still, it affects injuriously the germination of sets.

The practical method of dealing with the disease suggested from the experiments is to destroy diseased canes whenever noticed and to avoid diseased stools for seed purposes. This alone may prevent the disease from going beyond the sporadic stage in which it exists at present.

THE TUBE-WELL AND ITS IRRIGATION POSSIBILITIES.*

BY

F. H. VICK,

Agricultural Engineer, United Provinces.

THE climatic conditions prevailing in India, getting as we do, practically all our rainfall condensed into about 3 or 4 months of the year, with the remaining 8 or 9 months almost rainless, compel us to seek artificial means of watering the growing crops during the long dry period. We, therefore, rightly look upon the irrigation problem as an important one, and any methods of improvement in this direction will, I am sure, be welcomed by all who are in any way connected with the agricultural industry. We all of us then, in this meeting, start with a lively interest in the subject under discussion.

The tube-well is of many different sorts, but all have the same object in view, that of tapping the deeper and stronger springs of water. The kind we are mostly concerned with is of the strainer tube type, this being the most suitable for catching the percolation water in the deep sands underlying the whole Gangetic plain of this province. The ordinary pakka well is seldom sunk more than 30 feet beneath water level, and more often is only from 10 to 20 feet, so it does not always strike the copious springs of water in the lower strata. A hole is of course, frequently bored through the clay bed upon which a well-cylinder rests, thus getting the water from the first sand or water-bearing stratum beneath. In some cases, with exceptionally good conditions, such as a thick and strong clay bed above a thick stratum of coarse water-bearing sand, both being beneath subsoil water level, a very good yield of water

* A paper read at the United Provinces Co-operative Conference, held at Lucknow in February 1916.

is got, enabling a power pump to be used on the well, lifting as much as 8 or 10 *charsas*. Such places are exceptional though, and the great majority of wells in this province are giving two *charsas* of water or less. If at least a six *charsa* yield cannot be got from a well it does not pay to put in a pumping engine, the increased profit from the small area irrigated being insufficient to repay the initial cost of the plant and the running costs. This rule at once places most of the pakka wells of the provinces outside the useful limit for power pumps, unless they can be so improved as to cause them to yield a much larger quantity of water. We will consider later on in this paper the question of improvement of existing wells.

To return to the tube well. The difference then between it and the ordinary pakka well is that the former goes deeper, through successive beds of water-bearing sand, gathering the water from each bed, whilst the latter is shallow and draws its water from one sand bed only. The tube-well is generally sunk from 100 to 400 feet deep beneath ground level in this province. This may sound deep in comparison with the depth of ordinary pakka wells, but in reality it is not at all deep when compared with similar tubular wells in other parts of the world. In Australia, for instance, a lot of the borings are obliged to be from 2,000 to 4,000 feet deep in order to tap the underlying water, the strata above being all impervious to water and so being non-water bearing.

Although in this province we get, as I previously stated, practically all our rainfall in three months of the year, yet we are especially well favoured by nature with an inexhaustible supply of underground water, generally at a very moderate depth beneath ground level, to draw from to tide us over the dry nine months until the next rainy season. This underground water is stored up in the sand beds which extend to depths of thousands of feet beneath us, every cubic foot of sand containing roughly about one-third of a cubic foot of water. It will thus be seen what an immense supply of subterranean water we possess. It is not at all likely, so great is our supply reservoir, that any system of irrigation using more numerous and larger wells, can start to make an impression on our supply or even affect to any appreciable extent the subsoil

water-level. As long as our rainfall remains what it is, an average of over 40 inches a year for the province, our underground reservoir will be replenished annually and we need not fear drawing upon it to any extent necessary for irrigation. In a 40-inch rainfall something like 14 inches of water percolates through the upper strata down into our great natural reservoir and this is over the whole of the province. We lift for irrigation 6 or 8 inches depth of water for a *rabi* season and this only over about half the area of the province, say equivalent to 4 inches over the whole area. We thus see that far more water is annually put into our reservoir than we are ever likely to take out. It looks from these figures and statements, that the subsoil water-level would be constantly rising until we might suffer from a water-logged soil unsuitable for crops, but nature again comes to our assistance and provides a safety valve to let off the excess underground water, in the shape of numerous low valleys and river beds which act as great natural drains. Far more underground water drains off thus than we lift or ever will lift with extended systems of wells, for irrigation of crops.

Granting then our immense supply of water underground, we ought to study the question carefully as to whether we are making full use of this very excellent provision of nature, and when we compare the fine crops of canal-irrigated tracts with the poorer ones, and sometimes in the absence of winter rains the stunted ones, of some parts outside canal influence we are bound to confess, I am sure, that we are not doing all we should be in the way of water lifting. It is an extremely important matter, as only about one-fifth of the province is canal irrigated, leaving the other four-fifths to be watered by lifting from wells, *jhils* and *nadis*. There is no real reason why the crops of this province should not be as good and as paying in one part as another, whether within or without the area commanded by canals, were we to take full advantage of our underground store of water and employ modern methods of lifting it on to the land.

Areas irrigated from *jhils* and *nadis* are small in comparison with those watered from wells, so in this paper we will only consider the latter. What then is the best way of tackling the problem of

irrigation from wells ? At present with the existing wells small areas of 8 to 15 bighas are watered round each good well, and in order to irrigate more extended areas we should either want a very large increase in the number of pakka wells or should require each existing well to give much more water. The tube-well comes in here as the great agent for well improvement where wells are suitable for it. By sinking a big tube-well in a good existing pakka well, it can be turned at once from a two *charsa* well into a 15 or 20 *charsa* one. The well should have a depth of water in it of at least 25 feet, to be suitable for taking tube-well, so a great many wells cannot be so treated. However, the tube-well is just as useful in yield, and costs no more, when sunk by itself as if it is sunk in an existing well. No matter how difficult the subsoil conditions are, the tube-well, if sunk, is master of the situation. In some places what is called a " mota " a thick clay bed is not found at all at reasonable depths, nothing but sand exists to rest the well-cylinder in, for an ordinary pakka well. Such wells in sand always cause trouble. The sand flows into the well, which requires frequent cleaning out, and often the brick well-cylinder sinks and cracks. At the best not more than one *charsa* of water can be got from such a well. A situation like this is especially favourable for a tube-well, and success can be absolutely relied on with it.

Again in other parts the clay beds are so thick and deep that a pakka well cannot get deep enough, at reasonable cost, to pierce them and strike the deeper water-bearing sands beneath, even though a hole be bored in the bottom of well. Here too the tube-well will succeed, as if need be, it can be carried down 200 or 300 feet until the coarse water-bearing sand is met with

Regarding the cost of a tube-well, it varies according to the depth it has to be sunk. The boring must be continued until sufficient water-bearing sand is struck to give the requisite quantity of water. The cost is generally from Rs. 3,500 to Rs. 5,000. This may sound a high price when compared with that of a good pakka well costing perhaps Rs. 1,000, but compare the yield of water and it will then be seen that the tube-well is cheap. About 8 or 10 pakka wells at say Rs. 1,000 each would have to be sunk in order

to get as much water and irrigate as much land as one tube-well; so you get for Rs. 4,000 in tube-wells what you would have to pay Rs. 8,000 for in pakka wells. Further than this the price I mention for a tube-well includes a good engine and pump for lifting the water, and the use of a power pump will save the strain on bullocks at lifting water by *charsa*. The engine also can be used for other purposes besides pumping. For expressing the juice from the sugarcane a mill can be used, run from the engine, giving at least 10 times the outturn of the ordinary bullock mill. Or a small flour mill can be run and be made a source of profit. The area irrigated from one tube-well is about 8 or 10 pakka bighas a day or a total of 200 to 250 bighas in the season. The cost of the irrigation will of course vary with the depth from which the water has to be lifted. Taking 30 feet as the average depth from ground level to water level, at this depth the irrigation will cost about R. 1 per pakka bigha for each watering. Giving a *rabi* crop three good waterings during the *fasl* would thus cost a total of Rs. 3 per pakka bigha for the season, a cost which would be recovered several times over by increased crops due to proper irrigation.

Granted then that the tube-well is useful, and not costly for its output and utility, what is there to prevent its more extensive use? The main drawback is the very small holdings of the cultivators. A man cannot afford to put in a tube-well costing, say Rs. 4,000 which will irrigate easily 250 pakka bighas of land when he has only a few bighas of land himself to cultivate. The remedy for this is obviously co-operation, a number of men joining together to own a tube-well, and all getting water from the one tube-well in turn. This Conference is especially a co-operative one, and I would like to impress upon those present the very useful work that can be done by co-operative banks in sinking tube-wells. Success has hitherto been such that risk of failure may be regarded as negligible. There has been no single case of failure at all with our work in this province.

I am quite sure a tube-well is a sound investment and it is a form of well which I am certain has a big future before it in this province, the conditions being so eminently suitable.

AGRICULTURAL SAYINGS OF THE UNITED PROVINCES.

BY

V. N. MEHTA, B.A., I.C.S.,

Officiating Deputy Commissioner, Bahraich, United Provinces.

COLD weather touring is a great institution in these provinces and the officer who camps with his eyes and ears open will see and hear for himself in what a world of elemental hopes and fears the majority of the ryots move and have their being. They have the experience of untold centuries behind them and where this experience relates to agriculture they have for mnemonic reasons, set it to rhyme. These rough and ready rhymes escape their lips from time to time and when they hear you support your scientific explanations with an old world rhyme tried wisdom is imparted to it and it is accepted as gospel truth. On many a wintry evening have the old men of the village gathered round the camp of the present writer and talked to him about agricultural prospects. Agricultural rhymes have then accidentally fallen from their lips. The writer has collected these and others from *shagunbichar* books and privately owned manuscripts prescribing appropriate days for different agricultural operations. One Bhaddar Rishi is the general spokesman. Sometimes it is wisdom *à la Sahadeo* (the astrologer Pandava); sometimes it is the devoted wife nagging her patient husband to do something or forbear from doing something else.

In order that one may profit by this "wisdom"—full of empirical generalizations or occult pronouncements—a list of Indian Nakshatras or Lunar Mansions is given below with the names of the twelve signs of the Zodiac and it has been shown for Samwat 1972-73 for how many days each of these nakshatras lasted. The

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months given are Indian months but their English equivalents which vary will be easily available. There are 12 rashis (signs of Zodiac) which are divided into 27 divisions called nakshatras, each rashi containing $2\frac{1}{4}$ nakshatras.

Most of the sayings turn on rain—its normal fall or defect or excess. The first monsoon nakshatra is Mrigshar and commences from the Badi 10th of Jeth, 1972.

Indian Nakshatras or Lunar Mansions.

Constellation	Date on which the constellation begins	Sign of Zodiac	Date on which the sun enters the sign of Zodiac
* (5) Mrigshar (½) ...	Jeth Badi 10, 1972 ...	Mithun or Gemini.	June 14th.
* (6) Ardra	Jeth Sudi 9 ...		
* (7) Punarvas (¾) ...	Asarh Badi 9		
Do. (¼) ...	......	Kark or Cancer.	July 16th.
* (8) Pushya ...	Asharh Sudi 7 ...		
* (9) Ashlesha	Sawan Badi 8 ...		
* (10) Magha	Sawan Sudi 7 ...	Sinh or Leo.	August 17th.
* (11) Purva Phalguni ...	Bhadon Badi 6 ...		
* (12) Uttra Phalguni (¼) ...	Bhadon Sudi 4 ...		
Do. (¾) ...	......	Kanya or Virgo.	September 17th.
* (13) Hasta *alias* Hathia ...	Kuar Badi 4 ...		
* (14) Chitra (½)	Kuar Sudi 2 ...		
Do. (½)	......	Tula or Libra.	October 17th.
* (15) Swati	Katik Badi 2 ...		
(16) Vishakha (¾) ...	Katik Badi 14 ..		
Do. (¼) ...	......	Vrishchak or Scorpio.	November 16th.
(17) Anuradha	Katik Sudi 13 ...		
(18) Jyeshtha	Aghan Badi 10 ...		
(19) Mul	Aghan Sudi 9 ...	Dhan or Sagittarius.	December 15th.
(20) Purva Asharh ...	Pus Badi 7 ...		
(21) Uttra Asharh (¼) ...	Pus Sudi 6 ...		
Do. (¾) ..	......	Makar or Capricorn.	January 14th.
(22) Shrawan	Magh Badi 3 ...		
(23) Dhanishta (½) ...	Magh Sudi 3 ...		
Do. (½) ...	......	Kumbh or Aquarius.	February 12th.
(24) Shatatarka ...	Magh Sudi 15 ..		
(25) Purva Bhadrapad (¾) ...	Phagun Badi 14 ..		
Do. (¼) ..	......	Min or Pisces.	March 13th.
(26) Uttra Bhadrapad ...	Phagun Sudi 12 ...		
(27) Revti	Chait Badi 12 ...		
(1) Ashwini	Chait Sudi 9, 1973 ...	Mesh or Aries.	April 12th.
(2) Bharni	Bysakh Badi 9 ...		
(3) Krittika (¼) ...	Bysakh Sudi 8 ...		
Do. (¾) ...	......	Vrishabh or Taurus.	May 13th.
(4) Rohini	Jeth Badi 8 ...		
(5) Mrigshar (½) ...	Jeth Sudi 6 ...		

* Rain nakshatras.

N. B.—The number within the brackets indicates the chronological order of nakshatras.

The moon in the Puranas is represented as courting the 27 daughters of Daksha Prajapati for 14 days each. These nakshatras are the wives of the moon. It is also believed that they represent the ethereal bodies of pious persons after death and therefore they are expected to influence the affairs of men here below. The moon is the lord of aushadhis or plants and hence his journeys in the firmament are watched with special interest by the agriculturists.

The seven days of the week are presided over by the following planets:—

Sunday	... Sun	... Surya.
Monday	... Moon	... Chandra.
Tuesday	... Mars	... Mangal.
Wednesday	... Mercury	.. Budha.
Thursday	... Jupiter	... Brihaspati.
Friday	... Venus	... Shukra.
Saturday	... Saturn	... Shanishchara.

For the sake of easy reference these sayings have been abstracted here under three main heads.

(1) Rain prognostications.

(2) Agricultural operations, crop diseases, etc.

(3) General.

1. Rain Prognostications.

(a) *Interdependence between weather conditions in winter and summer on the one hand and rainy weather on the other.*

If on Katik Sudi 11th clouds and lightning are seen in the sky then there will be good rain in Asharh.

The appearance of clouds and lightning on Katik Sudi 15th with Krittika as the nakshatra foretells four months of good rainfall.

Katik Amawasya falling on Saturday or Sunday or Thursday in the Swati nakshatra is an omen of approaching famine.

Rain on the 8th day of Aghan is a good omen indicating copious rainfall during the whole of Sawan.

If the 7th of Pus goes without rain then during the Ardra nakshatra the sky and the earth will be one with rain.

If the Pus Badi 7th is without clouds or rain Sawan Sudi Punam will be a rainy day.

Lightning seen on the 10th of Pus is a happy sign of coming rain during the whole of Bhadon.

If it rains on the 10th of Pus Badi it is predicted that there will be a good rainy season.

If clouds are seen on all sides on the 13th of Pus Badi then Sawany Punam will be rainy.

If all the four directions are full of wind on Pus Amawasya, you must thatch your cottage well there will be plenty of rainfall.

The price of grain will be twice, thrice or four times dearer according as Pus Amawasya falls on Saturday, Sunday or Tuesday; if it falls on Monday, Friday or Thursday every house will be resonant with dulcet strains. (There will be plenty of grain.)

If on Magh Pariwa (bright half) clouds are seen on the horizon and the wind is blowing then Til (*Sesamum indicum*) and Sarson (*Brassica campestris*) will become dear.

Thunder and lightning on Magh Sudi 3rd is a sure sign that barley and gram seeds will be dear. If clouds are seen or if it rains on the 4th then *pan* and cocoanut will be dear.

Thunder on the Magh Sudi 7th, Pus Sudi 5th and the 10th of Aghan indicates that there will be four months of good rainfall.

The gentle wife speaks to the husband :—"If Magh Badi 7th is cloudy and lightning be seen, don't be moody, there will be good rainfall." (This the present writer thinks refers to winter rains or Mahawat and not to the good monsoon rains).

If the sky is of emerald green on Magh Purnmasi there will be seasonable rainfall. One female friend says to another "if no dew is seen on that day grain will be dear."

It is predicted from bright and clear sky in the month of Magh with Jyestha as nakshatra that all the seven staple kharif crops will be produced.

[The seven Kharif crops are :—

Kuri (early rice).
Kakuni (*Setaria italica*).
Mandua (*Elusine coracana*).
Sama (*Panicum frumentaceum*).
Makai (*Zea Mays*).
Kodon (*Paspalum scrobiculatum*).
Dhan (*Oryza sativa*)]

If on Phagun Sudi 2nd there be neither cloud nor lightning it will rain well in Sawan and Bhadon and you will enjoy Tij (Kajri Tij in Bhadon is a gala day for women).

Cattle suffer if Phagun Amavas falls on Tuesday.

If Phagun has 5 Tuesdays and Pus 5 Saturdays then alas for you, do not even sow your seeds.

If it is blowing from the west on the Holi day the whole earth will blossom forth; if from the east then the rainfall will be erratic, if from the south all the seven grasses will grow seasonably; if from the north there is sure to be good rain; if the wind is blowing from all the four sides then the ryots will suffer.

If there is severe dust storm (*rak* or ashes) on the 8th of Chait and if the 9th is wet and lightning appears there will be severe famine. The appearance of clouds and lightning on the 10th will be followed by failure of rain; but if the 10th is rainless the monsoon rains will be plentiful.

If seeds are wetted in Chait, and the petals of the beautiful *Butea frondosa* (Dhak) are washed in Bysakh and the sun shines at its hottest in Jeth, they forecast good rainfall.

Whatever be the length in Gharis of Chait Amawasya that will be the measure of the sale of unhusked rice in Katik.

If Revti is wet there will be no rains.

If Ashwini is wet there will be deficiency of rain towards the end of the season.

If on the 1st of Bysakh there are clouds and lightning then you can get very little value in exchange for 20 Jaipuris (old Asharfis).

Bysakh 3rd falling on Thursday augurs well for crops.

Wet Bharni is a bad sign, it will destroy even grasses.

If on the 5th the wind is blowing from the north then Bhadon will be a dry month. If no thunder is heard on the 6th then cotton will be dear. If the 7th ends cloudless there will be no rain on earth and no hope will be left. Ghee and oil will be twice as dear if the 8th falls on

Monday. If on the 7th there are clouds and rain there will be much rain in Asharh. If the 7th sees lightning, clouds and dewy precipitation, then all the four months will rain well. If the 7th is cloudless and 8th cloudy, Asharh (the principal rain month) will be dusty. Even big lakes will dry up if the 9th is cloudless and there will be no rain. If there is a Mandal or watery halo round the moon on the 9th move away your cottage, don't trust.

Wet Krittika is a precursor of plentiful fall at the end.

If Krittika rains grain will be dear, if Mrigshar rains then there will be bumper crops but if Rohini weeps then direst famine will follow.

If Krittika is dry and Ardra does not rain a drop Bhaddari is croaking and declares "you know very well that havoc will be wrought by famine." This is just the time for sowing Kharif crops and unless the means of irrigation are at hand absence of rain at that time is fatal.

The Moon has 27 companions but if only Krittika sprinkles the earth, everything is all right. If there be no wind during Mrigshar and Rohini constellations, if Jyeshtha does not bake (people) all round, then the fair lady (Gouri) will have to stay out on roads picking ballast stone.

Rohini nakshatra falling on Badi 10th prognosticates that there will be little rain and little grain; if that day is cloudy and it thunders "you, dear, go to Malwa" says the lady "and I to Gujerat." (Malwa in Central India and Gujerat in Western India are in popular imagination proof against famines.)

For winter rains it is said that if clouds come on Friday and stay on on Saturday then Bhaddar Rishi declares infallibly that they will not go away without raining.

It is not easy to say what the Bay or the S. W. Monsoon Current has to do with the N. W. Current well established in Upper India. But one has to live and learn and ultimately some connection will be established between the monsoon and winter rainfall.

(b) *Rain during the four months of rainfall and its effects on crops.*

If Jeth Parewa is hot and the 2nd thunders there is no doubt that the year will be a good one.

If Jeth Badi 10th falls on Saturday there will be no water on the earth.

Famine will follow if it rains on Jeth Sudi 3rd and the constellation happens to be Ardra.

If Rohini is wet and Ardra is windy then sell off your bullocks, there will be no profits in cultivation.

If Ardra is not rainy and Mrigshar is without wind Bhaddari declares that there will not be a drop of rain.

If the beginning of Ardra is rainy and Hast is wet at its tail then whatever tax the king may exact from the tenants the cultivating householders will be happy to pay. [The reason is simple. Early Ardra rains are required for rice and tail Hast rains for maturing kharif crops and preparing fields for rabi.]

East wind blowing in Jeth is a precursor of dust storms in Sawan.

If the month of Magh is hot while Jeth is cold and if tanks are filled up by the first rains then the poet Ghagh declares "Better be an ascetic (times will be hard for agriculturists while the ascetic will get his bread anyhow) because Dhobis will have to wash clothes in water drawn from the wells (rivers and tanks will be dry).

If Asharh Badi 5th is cloudless the dear one must go to Malwa to beg for bread.

The Bhaddar 9th (Asharh Badi 9th) falling on a Saturday is such a bad omen of impending famine that not a soul will outlive that year.

The Asharhi Punam has thundered and all the seven kharif crops will mature. If even the tip of the temple banner is wetted that day by rain there will be good times all round.

If the wind is coming from north-east on Asharhi Punam then, oh cultivator, sow your crops on uplands. (There will be plenty of water to inundate low cultivation.)

If the moon rises cloudless on Asharh Punam, you dearest go to Malwa, there will be acute distress here.

The wind blowing on the evening of Asharhi Punam in the middle of the sky or from the east, north or north-east is good. That from south-east, south-west or north-west is very bad.

The astrologer declares "Why are you cast down? Asharhi Punam has thundered and all the seven kharif crops will grow."

If Chitra, Swati and Vishakha rain in Asharh then husbands must go to another country, oh friend, for there will be a very severe famine.

If Pushya and Punarvas did not fill the tanks then expect rain next Asharh.

If the sun rises cloud-covered on Sawan Badi 5th, then move off your hut from the bank of the river.

If on Sawan Badi 5th it is blowing, then there will be a famine and birds in anticipation migrate to other countries.

If on the midnight of Sawan Sudi 7th there is thunder, then you dearest go to Malwa, I shall go to Gujerat.

If Chitra, Swati and Vishakha of Sawan do not rain down, garner grain; it will be worth twice as much.

Just as a child is not satisfied till the mother has served up the food so the soil is never satiated unless it rains in Magha. The Uttra has given her answer (in the negative) and Magha kept her maw shut, times were bad and Chitra gave reply and the situation was saved. (This is for rabi sowings.)

He who says that there will be rain in Magha, why he will see fruits on all plants.

Magha is proclaiming at every field boundary her influence and big and small, all rice stalks bear ears.

If on the Amawas of Bhadon a rainbow is seen in the west, there is the cry of 'alas.'

The east wind blowing in Bhadon will make rivers happy and boatmen ply their trade.

If east winds blow during Purva nakshatra, then even in dry river channels you will ply boats.

It is bad for Purva to be rainy.

It is said "He who says that Purva will rain down all the crops will be eaten by worms."

If it rains well in Uttra there will be such a bumper crop that even dogs will not eat the superfluous outturn. [In the western districts it is not necessary to have much rain after Uttra. Kharif crops have already matured and rabi soil is cooled down. However where there is transplanted rice Hast rains are wanted.]

Oh rice—you get hands and feet in Hast, in Chitra you get flowers and when Swati is coming on, you are spreading like a flowing robe. If Magha rains well, nothing more is desired. If not then you might wring your hands.

If Hast is rainy then wheat will grow up to the chest. [Hast rains cool the soil and if the moisture is well conserved by good tillage and producing a mulch at the top wheat will grow even without much subsequent irrigation.]

The elephant (play on the word Hast) has wagged his tail and the Jowari crop has been ripened without any more ado. (This especially refers to parts where September rains are most prized for maturing the kharif crops and cooling the ground for winter sowings.)

If it rains in Hast three crops prosper, Rice (Shali), Sugarcane and Urid (*Phaseolus radiatus*). If it rains hard in Hast three crops are ruined—Til, Kodon and Kapas.

If it rains in Chait three crops are spoilt, mothi, pulse (Urid), and sugarcane.

If there is rain in Swati and Vishakha neither will there be spinning nor will the music of cotton carding be heard.

A small fall in Swati (not a heavy and continuous downpour, otherwise cotton and dry kharifs will be ruined) is so beneficent that Kurmis (cultivators) will put on golden bangles.

If it rains in the middle of Pus the wheat plant will yield half its weight of grain and half its weight of straw. It will be a splendid crop.

Without Tula (sun entering Libra) rice ears will not appear.

If the eastern wind blows without ceasing and the widow puts on ornaments, as sure as anything, there will be rain and she will lead people astray.

Thunder in the south-west promises an early rainfall.

Rainfall will be plentiful if there is lightning towards Kampilya. (This proverb is of Etawah District.)

Partridge-coloured clouds with collyrium-like streaks on them indicate that there will be good rainfall.

If gusts of wind come like a hopping partridge then Bhaddari declares there will be good rainfall.

Good rainfall is also predicted if water gets warm by keeping, birds wallow in dust, and if ants migrate with their eggs.

If the moon is cloudy and the day is hot with sun and the eve bright with stars believe them as sure signs of famine.

If clouds start coming on Friday and bank upon Saturday there will surely be rain.

Crows cawing at night and jackals howling by day prognosticate that there will certainly be famine.

Rains when cotton is nearly ripe ruin the crop.

If the wind blows properly from south-west then you will get plenty of water at home. [This south-west wind is also called Banmura and Banda.]

If clouds overtake clouds on the horizon then Bhaddari declares that rain is imminent.

The howling of jackals during the day and the flowering of *kans* weed give no hope of rain. (*Kans* is flooded out and killed by good rainfall before it flowers.)

The Moharram which is associated in popular mind with burying of the old and the resurrection of fresh life has interwoven its importance into the lives of cultivators, be they Hindus or Musalmans, and therefore the fall of the 3rd of Moharram on any particular day of the week is carefully watched to draw omens from.

If the 3rd falls on Sunday, then there will be good rainfall, grain cheap and bumper crop of sarson (*Brassica campestris*). Trees will bear many fruits, wheat will be good, sesamum and grass plentiful and milch animals will prosper. Only cotton will be poor. But if the 3rd falls on Monday there will be half the normal rainfall. Grain will, however, be cheap, sesamum and cotton good and sugarcane plentiful. If it falls on Tuesday it will bring on unseasonable rainfall and famine. Fruits will be blown off unripe. Sesamum, sugarcane and cotton will be scarce. Servants will leave their masters and parents their children. Locusts will come. If the 3rd of Moharram falls on Wednesday, Til, Gehun (wheat) and Ganna (sugarcane) will be dear, but there will be plentiful melons and locusts. The same event coming on Thursday will give plentiful rains with good crops but the winter will be very cold. If it comes on Friday, grain will be cheap, there will be plenty of milk and a bumper crop of wheat. If the 3rd falls on Saturday, cattle will die in great numbers. [These prognostications about weather are given out by one Fateh Ali Bhaddari of Azamgarh District.]

(To be continued.)

NOTES.

Mixed crops. The Indian custom of growing gram and wheat together as a mixed crop is well known and has often been described in the literature. The practice is particularly common on the black soils of Peninsular India and also in the tract comprised by the Western Districts of the United Provinces and the Eastern Punjab. The advantage in mixing the crops is generally considered to be the insurance obtained against an entire failure of the harvest in years of short moisture. Under such conditions, the deep tap root of gram is supposed to reach the lower layers of the subsoil and to abstract moisture therefrom.

The mixture, however, has another advantage and this is concerned with the nitrogen supply. On the black soils of the Peninsula, it is exceedingly probable that denitrification is common during the monsoon phase, and that the amount of available nitrogen is small at the time when the *rabi* crops are sown. In November and December, the wheat crop in this region looks very thin and pale, and the foliage is wanting in that robust appearance characteristic of wheat grown on land moderately rich in available nitrogen. If the supply of nitrogen is limited, it would obviously be a great advantage to the wheat to be grown mixed with a crop like gram which is able to make use of atmospheric nitrogen and so relieve the pressure on the combined nitrogen. A similar state of affairs exists in Northern India. The marked response of wheat to organic manures on the somewhat sandy loams of North-West India, where wheat and gram are grown together, indicates that here too it would be an advantage to limit competition for the nitrates dissolved in the soil water.

An interesting confirmation of these ideas has just been obtained in the Botanical Area at Pusa. Of late years, a number of new wheat crosses have been worked out between Indian types of high

grain quality and rust-resistant, strong-strawed English kinds. The work is now in the sixth generation and new rust-resistant forms have been fixed with exceedingly strong straw and vigorous rooting power. These withstand wind, retain their erect habit up to ripening time, and stand out in strong contrast to ordinary Indian types which always lean away from the prevailing wind. The single plants of these crosses were sown as usual grain by grain in October 1915 in small plots of three lines each and the cultures were separated from each other by a line of gram. The field was therefore a mixed crop of wheat and gram in the proportion of three of wheat to one of gram, a mixture, as regards the relative amounts of the two constituents, not unlike that often met with in practice.

As the wheat ripened, a curious phenomenon disclosed itself all over the culture field. The outer lines of wheat of each plot next to the gram were distinctly taller than the middle line and appeared to be more vigorous. These lines were growing in soil next to the gram and therefore would be expected to obtain more nitrogen than the central line of each wheat plot. At harvest time, weighings were made of the seed of 20 plants taken from the middle line of plots and from the corresponding outer line next to the gram. The first of these plots was about the centre of the field where the soil was not very fertile. The second was towards the southern end of the culture field where the natural fertility was considerably greater, due to accumulations of silt formed by the natural terracing of the field. Care was taken to select representative samples of the whole. The results were as follows, the weight of the seed of 20 plants being expressed in grammes :—

	Row next to gram	Inside row	Percentage increase
1	178·4	108·5	65
2	302·0	241·2	25
Total	480·4	349·7	Average 45

The total difference in favour of the wheat next to the gram is therefore 130·7 grammes and the average increase is 45 per cent.

Weighings were next taken of the grain of the whole of the outer and inner lines of two cultures from the southern end of the field. The results, in grammes, are given in the next table :—

	Outer row	Inner row	Outer row
1	594	470	635
2	661	548	621
Total	1,255	1,018	1,256

In the first case, the average increase of the outer lines above the middle line is 145 grammes or 30 per cent. In the second case, taken from the most fertile corner of the culture field, the average increase is less, namely, 93 grammes, or 17 per cent. It will be observed that, in all cases where the soil, judged by the vigour of the wheat crop, was richest, the difference between the yield of the inner and outer rows is less. This fact supports the explanation that these differences are due to the nitrogen supply of the wheat. Taking all four determinations together, the average increase in grain production of the lines next the gram is 34 per cent. above that of the middle line of each plot. The figures indicate quite clearly that there is a marked advantage in growing mixed crops of gram and wheat on soils where combined nitrogen is a limiting factor.—[A. Howard].

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The effect of Sulphur on crops. Attention was drawn in April 1914 in a note in Vol. IX, Part 2 of this Journal, to certain observations on the effect of sulphur on crops, and it was suggested that it would be worth while testing the effect of sulphur on soils where it had not been previously tried.

In 1915 such tests were made on the Ranchi Farm, quantities of sulphur from 10 to 40 lb. and gypsum containing some 30 lb. of sulphur per acre, being severally applied to a large number of plots of groundnut.

The effect was in every case very remarkable, the gypsum producing an average increase of 8 maunds per acre of groundnut,

and the plots to which sulphur or gypsum was applied being very much more luxuriant than the control plots.

As far as could be judged by appearances, 10 lb. of sulphur per acre produced as much effect as 40 lb., but the larger quantities gave slightly larger yields of nuts.

Twenty pounds of sulphur per acre applied to rape also produced a remarkable effect, the crop being very much more luxuriant and continuing to flower for quite a fortnight longer where the sulphur was applied.

In a paper in the *Journal of Agricultural Research* (Vol. V, No. 16, of January 17th, 1916) Walter Pitz, Assistant Agricultural Chemist of the Agricultural Experiment Station of the University, Wisconsin, shows by pot experiments with two soils, that small quantities of calcium sulphate may increase the growth of legume bacteria and the yield of red clover—an increase which is accompanied by a greater root development and an increase in the number of nodules. The smallest proportion of calcium sulphate used in his experiments would, however, even if calculated only on the top 4 inches of soil, connote an application of more than five times the largest quantity used per acre in the experiments at Ranchi; and it would seem probable that, in laboratory experiments with sulphur, increments of the order of 0·001 per cent. of the weight of soil would give more useful results than increments of ten times that magnitude.

The *Monthly Bulletin of Agricultural Intelligence and Plant Diseases* for December 1915, contains (p. 1629) an abstract of a paper by F. C. Rimes, Superintendent of the Southern Oreyon Experiment Station, on the effect of sulphur on alfalfa at that Station.

Many references are also given to previous papers on this subject.—[A. C. DOBBS].

* * *

AN interesting note by Mr. Barnes, Agricultural Chemist, Punjab, has been received dealing with the **mineral constituents of cotton lint.** It arose from the supposed adulteration of raw Chiniot cotton by the addition of earth salts to increase the hygroscopic

properties and the investigation of such a possibility led to the discovery that the inorganic constituents of this cotton fibre were far more variable than had hitherto been supposed and the large percentage of magnesium chloride it contains seems likely to seriously affect the reaction of the fibre to dyes.

We quote Mr. Barnes' summary *in extenso* as it points to another factor which will have to be considered by the grower, breeder, and buyer.

"There appears to be no evidence of the reported practice of salting the cotton to increase its water holding capacity. Mr. Arno Schmidt reports that he has seen watering of raw cotton actually taking place, but this is a crude form of sophistication, and will certainly lead to deterioration of the fibre and cannot but come to the notice of the buying agents of exporting firms in India. It will thus rebound immediately on the persons practising this fraud and can be dismissed from the scope of this enquiry.

"The complaint of Messrs. Volkart that the Chiniot cotton contains an unusually high percentage of magnesium chloride seems to be true, but we do not think that this substance has been artificially added, for the analysis of sample No. 53 shows that it compares with other genuine samples in the amount of water and mineral matter which it contains. The assumption that cottons grown on saline soils will produce a fibre more heavily impregnated with mineral matter does not seem to be justified by the results, for alkaline soils are much more prevalent in the Punjab than in Bombay.

"The total amount of ash material in cotton fibre seems to have been under-estimated by previous workers who seem to have assumed that this was largely due to foreign mineral matter in the form of dirt in the baled cotton.

"The presence of highly varying quantities of silica especially seems to have escaped attention. I am inclined to lay considerable stress on the established fact that genuine cotton fibre may contain upwards of one per cent. of ash, and that the composition of this ash is variable and variable to a far greater extent than has hitherto been supposed.

"There is little doubt but that this will seriously affect the reaction of the fibre to dyes—how far it will affect the tensile strength and keeping qualities of the fibre remains to be shown. It is evidently a factor which both grower and breeder must take into consideration, namely, the nature and quality of the mineral salts taken up by different varieties of cotton grown in the same soil, and under the same conditions, and how far climatic variation will effect this, as well as the effect of these mineral constituents on the commercial value of the fibre."

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Abortion Bacillus. The remarkable discovery of G. C. Schroeder and W. E. Cotton on the persistence of the abortion bacillus in the milk of cows, and particularly the demonstration of the fact that in one case it was eliminated from a cow's milk for four and a quarter years, is a most interesting contribution to what was already known concerning the bacillus. As far as our preliminary investigations have gone in this direction, we find that the bacillus is present in the milk of cows in the herds we are using for our work, and this milk injected into healthy guinea-pigs does produce pathological lesions and death.

We collected in November last year a number of samples of milk from cows which were known to have aborted. Utmost regard was given to asepsis in order to eliminate all possibilities of extraneous contamination. Sterile tubes were filled by squirting the milk therein from some distance. With this milk guinea-pigs were inoculated intraperitoneally with quantities from 5 to 15 cc.

Before injecting the milk was warmed to prevent shock. We find that guinea-pigs can accommodate large quantities of milk without any discomfort. Workers in this laboratory have used as high as 30 cc. without untoward results.

The first guinea-pig died on the thirty-sixth day following the infection, the second on the forty-fifth day, and several between this later period and the fifty-sixth day. *Post-mortem* examinations of these pigs revealed the characteristic enlargement of the spleen. The lymphatic glands presented signs of degeneration. The liver

was enlarged, with whitish spots throughout its substance. In some of our guinea-pigs the characteristic changes in the organs were not so pronounced as recorded by Schroeder and Cotton, but this may have been due to the cold quarters reducing the vitality of the small animals, so that they died before any great degenerative changes had taken place. Further, our organism may be of a greater virulence. In all our autopsies the clinical lesion in the spleen was taken as suggestive of infection, and it was from this organ that our cultures of abortion were obtained. Spleen pulp spread over the surface of the solid tube media gave excellent growths in reduced oxygen. The bacillus obtained in these cultures possessed more rapid growing qualities than those obtained from material in the original host (the placenta and uterine contents).—*Report of Veterinary Director-General, Canada.*

***

Root Pruning. This operation is performed in the case of those fruit trees which make a free growth, but produce little or no fruit. This operation also requires skill and experience. To do this properly, dig a trench in winter 3 feet deep around the tree and about six feet away from the main stem. Any root met with while digging the trench should be cut back to its inner side. If only few roots are met with at the above-named distance from the main stem, then dig gradually closer to the latter all around until you reach a point where root growth is profuse. Then cut off all the main roots to be seen with a sharp knife. When this has been done, mix the turned out soil with one or two dozen baskets of manure and return it to where it was taken from.—*The Fruit Garden in India.*

REVIEWS.

The Milk Problem in Indian Cities. By LEMUEL L. JOSHI, B.Sc., M.D., Municipal Analyst, Bombay. Published by Messrs. D. B. Taraporevala Sons & Co., Bombay. Price Rs. 5.

IT cannot be said that this work is an addition to the literature on the question of milk supply in the East as it really is the beginning of reliable written records and conclusions on the all-important subject of the milk supply to Indian urban communities. Dr. Joshi has a wide experience of the subject from the public health point of view, and although to some extent he deals with the technical or dairying side of the question the book cannot be regarded as a work on dairy technology, but rather as a lead for the educated public in general, and those engaged in safeguarding public health in particular, on the milk question in cities.

The picture which Dr. Joshi draws of the present condition of the dairy industry in India corroborates the findings of the Board of Agriculture at their Coimbatore meeting, and in no way does the author overstate the case here. After reviewing the present conditions of city milk supply, Dr. Joshi goes on to describe what he considers to be the reasons for the existing deplorable condition, and then he suggests certain remedies. The conclusions drawn as to the cause of the existing state of affairs are sound generally, and Dr. Joshi classifies remedial measures under three heads:—

(1) Economic, educational, and general measures.

(2) Sanitary measures.

(3) Legislative control.

In connection with (1) the author materially gives prominence of place to the breeding, rearing, and tending of a dual purpose

cow for India, or in other words, a breed of ox of which the males will be suitable for draught and the females for milk production.

The question of improved feeding, housing, and general care of the animal is fairly fully dealt with, and the difficult problem of the organization of cow-owners for the purpose of selling their produce and generally applying modern business methods to the industry is discussed. Co-operation is recommended as a means of solving this end of the problem, and it is a pity that Dr. Joshi did not give us more details as to how such co-operation might be applied in India. Throughout the work he quotes freely what has been done in other countries, and he might well have given more particulars of how co-operative methods have been applied to the needs of the dairy industry, especially city milk supply, in Europe and the Colonies. Not only so but the knowledge and experience Dr. Joshi exhibits throughout this work would well enable him to enlighten us as to how foreign co-operative propaganda could specially be applied to Indian conditions. Various measures to be undertaken by the State in the direction of educating the cow-owners and the public are discussed, and the author's suggestions here generally follow the lines of the recommendations of the Board of Agriculture.

Dr. Joshi rightly believes that the economic, sanitary, and other measures advocated should take precedence of legislative action, but he regards the latter as a necessary corollary of dairy educative propaganda. His recommendations as to the fixing of standards of quality are in the main sound, and the difficulties of differentiating between cows' and buffaloes' milk and fixing standards applicable to both are dealt with. The question of estimating the cleanliness of milk by its bacterial contents is very fully discussed, but although the author is cautious in his recommendations as to fixing standards of bacterial contents, here the practical dairy expert will not follow him, until it is more clearly established that the figures given as quantities of germs present in given quantities of milk are really what they represent, and until this fact can be readily demonstrated to the ordinary well trained dairy manager.

On the whole, the work is a sound treatise on an all-important subject, and the conclusions drawn by Dr. Joshi might with slight modifications be taken as the basis of dairy reform here.—[W. S.]

* * *

Well Waters from the Trap Area of Western India. By HAROLD H. MANN, D.Sc., Principal, Agricultural College. Poona (Department of Agriculture, Bombay. Bulletin No. 74 of 1915). Price As. 6 or 7*d*.

INDIA is at times visited by severe droughts which affect considerable tracts of country, and cause much distress to the agricultural population. Government tries to render the work of the cultivator as far as possible independent of the variations of the season by the provision of suitable irrigation facilities. By anicuts and canals fullest advantage is taken of the waters in many of the great rivers. Irrigation from wells is also made use of to a considerable extent and has the advantage of being cheap enough to be within the means of the cultivator.

In Western India, except for a comparatively small area. served by canals and tanks, almost the whole of the irrigation is conducted from wells. The total number of wells is enormous and they are a very important factor in the agriculture of the country.

The problems presented by well-irrigation are hence worth a closer investigation in their chemical. geological and engineering aspects than they have received in the past. Dr. Mann's paper is therefore very welcome.

In the trap area, the water in a well is almost always what may be termed "fissure water," that is to say, it is not a generalized subsoil water which is tapped, but water flowing in definite fissures in a definite direction. In digging a well one has to take his chance of meeting a fissure containing flowing water. This makes any attempt at digging an ordinary well by tube boring or by any other means of digging a *narrow* trial hole, of very uncertain value, unless the presence of water has been made fairly certain beforehand.

The above is, of course, the general case. But there are a considerable number of enclosed valleys even in the typical trap area where there is a generalized underground water supply over a limited area.

Analyses of typical well waters are given by Dr. Mann. Attention is drawn to the fact that the application of certain well waters makes the soil very impervious to water and hence very hard and difficult to wet. In such cases the waters contain a large quantity of alkaline bicarbonate and a small quantity of other sodium and potassium salts. If chlorides or sulphates in larger quantity accompany these alkaline bicarbonates, they are relatively innocuous: but if the bicarbonates of the alkalies are present in quantity greater than the chlorides, they are injurious. The actual effect seems to be a destruction of the tilth of the soil owing to a deflocculation of the colloid clay material so that on mixing with water the solid matter remains suspended for practically an indefinite period.

As to the amount of dissolved salt in the water which will render samples of water unsuitable for irrigation, it has been found that, so long as these do not contain a large excess of alkaline carbonate or bicarbonates in excess of the amount of lime salts and of the chlorides and sulphate, well waters are useful for irrigation until the amount of salt reaches 200 parts in 100,000 (or 0·2 per cent.)

At Dhulia a systematic study has been carried out to ascertain to what extent the character and quantity of salts vary at different times of the year in the same well. The extraordinary constancy in the composition shows that the water which is drawn up from rock fissures in wells like that at Dhulia is not surface water, but represents the tapping of a very considerable underground water reservoir. This might have been also concluded from the fact that the supply, though diminishing in the hot months, never ceases.

An examination of the waters of some wells near Surat proved the interesting fact that in this part there is not a general reservoir of subsoil water. The water differs in composition and depth in different wells within a short distance from one another. When

a well is emptied the water usually flows into it chiefly, if not entirely, from the eastern side.

Nearly all the wells in this part of Gujarat are somewhat salt due to a continual seepage from the sea. During the famine years (1896 and 1900) the sources from which the wells in Gujarat are usually supplied were dried up and many of the wells gradually became salt. Many have remained so, and useless ever since: others have gradually after several years become sweet again. This can only be the result, it seems, of sea water coming in, when the fresh water current from the East, which usually kept it back, failed. The effect of short rainfall in Gujarat on the character of the water in the wells is thus serious and the permanent effect of a long drought may not be limited to its action on cattle and men. It follows also that there is much danger in utilizing too great a proportion of the water available in such wells, and the haphazard use of well water for irrigation purposes ought to be put a stop to.

The author is to be congratulated on this excellent work and the results of his further studies will be awaited with considerable interest.—[J. S.].

* * *

A Soil Survey of the Guntur Delta. By W. H. HARRISON, M.Sc., and B. VIŚWANATH, Bulletin No. 70, Department of Agriculture, Madras. Price R. 1-8 or 2*s.* 6*d.*

THE importance of a systematic study of the field differences in soil is recognized by all interested in agricultural work. Not only is the result of the soil survey of a locality of great help to the practical farmer, but it also is of use to a wider public in as much as it furnishes an important factor for the determination of land values.

Dr. Harrison and his assistant have just published a second instalment of the result of their survey of the Madras soils, the first referring to the soils of the Tanjore delta (Bull. 68). The present work deals with that portion of the delta of the Kistna river which lies in the Guntur district and is under the Kistna irrigation project. 111 samples of soil were collected from typical fields whose recent

manurial history could be obtained and which are under paddy cultivation.

The results of the analysis, which consists of the estimation of lime, magnesia, nitrogen and total and available potash and phosphoric acid, are entered in a table and also shown graphically in maps of which there are many.

A study of these maps is very instructive and serves as a guide to the manurial requirements in different areas.

It is seen that the nitrogen content of the delta soils is low and the introduction of special manurial methods with the object of rectifying this would lead to great benefit. It is further seen that the effect of the river silt profoundly modifies the manurial character of the soil of the delta. The silt of the Kistna river is rich in lime and magnesia and total potash and phosphoric acid, and therefore it would be expected that the soils which come under its influence would materially differ from those not affected. Thus it is found that the coastal soils and those in the centre of the delta are generally clearly demarked and are of the poorest quality. This fact would appear to furnish an argument in favour of the conservation of the river silt.—[J. S.]

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PLATE XXI.

SIR EDWARD CHARLES BUCK, K.C.S.I.

In Memoriam.

Sir Edward Charles Buck, K.C.S.I.

In the early days of July intimation reached Simla that Sir Edward Buck had died in Rome where he was attending the meetings of the International Institute of Agriculture as representative of Great Britain and India. Thus did the veteran end his days as he would have wished, faithful to the trust which he made his own nigh fifty years ago.

The name of Sir Edward Buck will always be associated with the establishment of an agricultural policy for India. He may not have had that close association with agricultural experiment which has become the feature of more recent years. But he laid the broad lines of principle on which have been built up our Agriculture, Settlements and Land Records, Statistics and Famine Relief, and he is responsible for the sound foundation upon which the general revenue system of the Indian Empire rests. It was not his to see the later fruition of his efforts in the great expansion of agricultural investigation which came with Lord Curzon's Government, for he retired from the service in 1897; but to the end he kept in touch with its activities, and nearly every year personally saw its progress in his loved Provinces of Agra and Oudh.

Sir Edward Buck was a great personality, full of ideas and of extraordinary singleness of purpose. His whole career was devoted to Revenue from the days that he arrived in the North-West Provinces as an Assistant Collector in 1862 till he retired, after 15 years' service in the Government of India, in 1897. In his retirement he still kept up his interest in India and its problems, and his name will always be held in affectionate remembrance not only by the hosts of Europeans and Indians who enjoyed his personal friendship, but also by all who have at heart the real development of India. He was "a very perfect gentle Knight" and his memory will for long remain green. May he rest in peace!

EDITORIAL.

WITH the next issue of this Journal we shall introduce certain changes which we trust will tend to popularize it. Through the eleven years of its existence the Journal has maintained the high standard of excellence with which it started. That standard, it is hoped, will be continued; but there is a feeling that the Journal might, without detriment to its traditions, be made of more general and popular interest. While therefore it will contain, as in the past, articles on specific agricultural and scientific questions, an attempt will be made to widen its scope so that it will be more the Journal of the Agricultural Departments and of the agricultural workers of India.

We shall therefore welcome contributions from all who are interested in Agricultural and Veterinary matters, Irrigation problems, Co-operation and Agricultural Economics and, in particular, from those who have the practical problems of agriculture to face—the Planting Community and the large Zemindars of India. To them our columns will always be open, and we shall welcome all enquiries or criticisms they may address to us.

On this broader basis we trust that the Journal will enter upon an era of increased popularity and prosperity.

THE CONTROL OF FLIES AND VERMIN IN MESOPOTAMIA.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Lately Entomologist in the Imperial Department of Agriculture for India.

[WE have much pleasure in publishing this article from the pen of our former colleague Prof. Maxwell-Lefroy.

The Indian Agricultural Service—both European and Indian—has responded nobly to the Nation's call and our best wishes follow the present detachment of eight Pusa Assistants who have volunteered for service in Mesopotamia. May much success attend their efforts to alleviate the conditions in which our gallant troops are living, and may they return safe and sound, with the consciousness of a duty well performed.—(*Editor.*)]

THERE have been urgent reasons for dealing with flies and vermin among the forces in Mesopotamia this year, and I was fortunate in being sent up at the end of April to investigate and decide what could be done. Even on the way up, there was entomological work to do. The hospital ship on which I travelled from Bombay had been long in the tropics and was full of small red ants which were a sore trouble to the wounded and sometimes worse. As the ship was going up empty, there was full scope for work and after failing with one method, we succeeded with another. Baits were put down (usually syrup on rags) and the trail of ants to the nest traced back. The nests are all behind wood-casings and the cracks of exit were oiled with a mixture of paraffin and lubricating oil. This isolates the nest inside with the queens and the workers outside cannot bring food in. In three days there were no more trails or nests discoverable and the plague was under control.

Basrah was hot and stuffy but not markedly plagued with flies; but as one goes up river it gets worse at every camp till the climax is reached at the most advanced post where Corps Headquarters are situated. The flies are mostly the Housefly type, *Musca*, of several species probably, a few Blow flies of the *Calliphora* type, and some *Stomoxys*. The last is a nuisance on the river as it bites so sharply but it is not a disease-carrier and is not really common on land.

To fully appreciate it the abundance of flies has to be seen and still more to be suffered. The tents and trenches are full of them. By night they sleep in masses on tent roofs, etc., in the morning they awake to furious activity as soon as the sun has warmed them, till midday they feed and fly and buzz; then they seek deep cool shelter if it is hot, say over 110° F. in the tent, and go to sleep. In my tent they preferred to get under the bed on the sides of the pit in which one lives. At evening they start again and are very active from 5 to 7. When one has been driven crazy, it is good to go and see the patient resignation of the sick and wounded and therefrom to learn control and resolve more strenuously to destroy the scourge. And then one remembers that nearly every disease in Mesopotamia is one that is carried by water and flies only, and one realizes that the fly is really a serious factor in this campaign.

Another entomological problem is of some importance in Mesopotamia, and this is the control of vermin and sand-flies, fortunately no difficult matter. The former convey relapsing fever and typhus, the latter carry sand-fly fever; both are the cause of irritation, the sand-fly especially; there have been cases of serious septic sores from sand-fly bites and the sand-fly has been one of the real plagues of life. Fortunately there is a cure for both. In 1904, the use of Crude Oil Emulsion was first introduced by the Entomological Section for vermin on animals; early in 1915, a refined form of this was shown to the War Office, and in May was adopted as the official vermin remedy for the army. It is now being made in large quantities in Bombay and sent up to Mesopotamia. In the Army it is known as "Vermijelli," but as this is a

registered name, the property of a firm in London, it is called "Sand-fly and Vermin Ointment." It has the merit of keeping off sand-flies and mosquitos, if rubbed very lightly on the hands and face. I had one tube with me in Mesopotamia. I did not realize the sand-fly was there and was badly bitten the first night; I was never bitten again, I used no net and all who shared my tube found the same. It is now being issued for this purpose. For vermin the emulsion is rubbed on the hairy parts of the body and on the seams of clothing; under-clothes are washed with it and dried without rinsing so that the clothes are lightly impregnated with it.

With regard to flies there are really three problems in Mesopotamia, the control of flies in camps, trenches, etc., in towns and with moving bodies of troops. The first is the important one because it is the biggest and, in some ways, the easiest to deal with. The breeding places in camps, trenches, etc., are of three kinds. The latrine trench is far the worst, accounting for probably 90 per cent. of the flies; the accumulations of stable manure, and the accumulations of refuse and offal account for the rest. The latrine trenches are about 18 inches deep, a foot long, six inches across; a series are dug side by side, according to the number of men. They are filled up daily. They offer the ideal breeding place for flies and they swarm with flies laying eggs when they are in use and are solid masses of maggots in a few days. Flies emerge from trenching ground in hordes, get their first meal at the nearest trench then in use and then distribute themselves over the camp.

Stable manure was comparatively harmless owing to rapid desiccation; only when small amounts were swept up with dry litter and so preserved from drying did one find maggots and the manure is nearly all dried and burnt. Kitchen refuse and offal are usually burnt or buried but would easily breed flies. The greatest care is usually taken and it is only carelessness on the part of the sweepers or camp cleaners that allows this material to breed flies.

In most places in Mesopotamia there is absolutely no other source of fly breeding; the land is flat, dry, absolutely barren as a rule; there is no shade, a fierce sun bakes it, a dry wind blows furiously. Only where man is, can there be shelter, food or breeding

places and there is no man but soldiers in the war area. There are stories of bodies of men trekking into the bare open country and finding hordes of flies, but they took these with them. When one comes out of the trenches, flies settle on all the areas shaded by one's *topee* or oneself and on all the shady parts of one's horse; they travel on one thus for miles, unable to fly away in the fierce sun. In this way one carries swarms of flies and a body of men, when they camp, will naturally find their tents full of flies.

No place strikes one as so easy to clear of flies as a camp, as all is done in full view, there is nothing hidden and one can control everything. There are no houses, no back-gardens or filthy alleys, no refuse dumps or collections of rubbish. It is a matter of deciding what to do and having it done.

The second problem will be more difficult because it is not so easy to control a town. In Basrah and Amarah there are large areas of camps, with streets of houses not far off; the problem is not so simple because of the uncontrolled breeding places of the native houses, and it is more a question of extensive fly killing (as described below) than of prevention.

The third problem again is difficult because of the limited resources of a moving body of men. Such a body of men will not suffer from the flies they breed; they suffer from the flies bred by other moving forces before them and there are camping grounds on lines of communication where you arrive to find that swarms of flies greet you and millions are then emerging; that means that ten days before a body of men camped there, used latrine trenches, and probably did not trouble too much about the disposal of kitchen refuse and offal.

Having examined the problem and especially having seen what was needed for the trenches, the field hospitals and the head-quarters and other camps, it was a question of getting supplies and a staff of men to carry out the obvious measures. All the supplies that went with me from Bombay were snapped up at once and much more was needed. Everyone in charge of hospitals particularly needed help and supplies; it is a real experience to go round the tents of a cholera or ordinary hospital, and to see what a curse

the flies are to the men. Then one sees the operating tent and realizes that flies may come 100 yards from a nearby latrine to vomit their last food on the exposed tissues of a patient; one sees flies settling on a fresh wound, and the men fighting them off while it is dressed. No wonder every single person is keen to help the fly campaign and that every possible assistance is being given to those who are trying to reduce this pest.

A short simple set of instructions was prepared and issued; the measures recommended are discussed here in turn.

1. As far as possible, replace latrine trenches by tins and incinerate. This system is very widely used: tins are sunk in the ground to receive fæces; nearby is a small round incinerator consisting of a circular wall three feet high with a grating across of iron rods and two air inlets below; dry litter and any dry material is put in, lit and it burns slowly; on this the material is incinerated. This is not always possible particularly in the trenches; but one battalion had an incinerator for its front line latrine: and where this can be done it is the proper thing.

2. Where incineration is impossible and deep trenching is impossible, then each latrine trench must be treated. After trying pesterine and fuel oil without effect, it was found that ordinary burning oil, as issued there, was effective; a trench treated with oil does not get infected with maggots and if oiled when it is filled up, many maggots are killed. There is much oil available, the crude lighting oil of the Anglo-Persian Oil Co., obtainable near Basrah, being quite suitable.

3. Oil should be used even with tins as it prevents flies settling and feeding on the excreta. A great deal of the diarrhœa and intestinal diseases prevalent must be carried by flies directly from the fæces of infected men and oiling prevents that.

4. Kitchen refuse and offal are to be burned or oiled and buried. This is obvious and is rendered more important by the fact that a great many goats are slaughtered by native regiments, in their own way, anywhere near their lines. There is a great deal of indiscriminate goat-killing going on wherever there are native

units and this material would breed flies. The absence of blue-bottles shows how careful the men are in this matter.

5. Horse and mule droppings are to be collected and burned or spread out to dry. As a rule the droppings are wanted for the incinerators. The heat and dryness are such that in a very short time, house manure is too dry for flies to breed in it; the only trouble has been with the individual *saises* of officers' horses who may be careless and breed a quantity of flies; where there are regular horse or mule lines the greatest care is taken.

6. Trial of fly poisoning with sodium arsenite showed it to be an extremely effective method; fortunately I had been able in Bombay to get 50 tins of weed killer, which was crude arsenite and worked very well.

A mixture is made of arsenite half a pound, *gur* two and a half pounds, water two and a half gallons. This is a convenient amount for a kerosine tin. In this a gunny bag was dipped and hung up. A shelter tent or a covering of mats is advisable or the flies will not come in the hot part of the day, and the gunny bag must be kept moist. Flies come in swarms, feed and die there on the spot. The solution is weak enough not to affect them till they have fed; if made too strong, they are affected before they get a fatal dose. It is possible to fit up strips of gunny on the roller towel principle so that it dips in the tin; as it dries and gets too concentrated water is added.

This simple poison, devised originally by Dr. Berlese of Portici, Italy, works beautifully; the flies are thirsty and hungry; they smell the *gur*, they come in shoals; blue-bottles come as well as *Musca*. The slaughter is very great and the effective range appears to be at least 200 yards and is probably much more. This means that to keep a camp clear one wants a fly-poisoning station every quarter of a mile or so. By having the poisoning done in a separate place there is no risk from dead flies and it is best to put the poison at a point between the latrines and the camp.

7. In the trenches flies collect in masses at certain places at night and at midday. They particularly like canvas or tarpaulin coverings and sheltered corners in dug-outs. With a spraying

machine and suitable liquid, one can kill flies in bulk. The choice of liquid is easy; two only are at present known, both of which have been extensively used in Europe and Egypt since they were discovered last year. For the trenches we are using the oil-spray, a special grade of mineral oil to which is added a small amount of aromatic essential oil such as citrovella. In England this is sold as "Flybane"; in Bombay, thanks to the help of the managers of the Standard, Vacuum and Asiatic Oil Companies, the nearest grade of oil to that selected in England has been found and is being used.

8. Hospital tents and buildings require other methods. Formaline can be used for fly poisoning; but the "Miscible fly spray" used in Europe and Egypt will probably give the best results; it is undesirable to use the oil as it taints milk and food; but this new fly spray, whose laboratory name is *Exol*, is being sent up for hospital use. It is not poisonous or inflammable and has only a slight smell; it does not taint food. It is mixed with water and sprayed in the air. Flies fall to the ground paralysed or dead. It is not yet certain whether the formula used in Europe will succeed in Mesopotamia owing to the very high temperatures but this has to be ascertained and the formula varied if necessary. Thanks to the Medical Store-keeper at Bombay, large quantities of this have been made. At the request of the War Office the formula of this spray has not been published as the ingredients are not unlimited in supply. When the Army has had all it needs, the formula will be published and the public can get the liquid.

For hospitals, an ample supply of netting, mosquito nets, etc., has been essential. It is absolutely necessary to prevent flies getting at the excreta of cholera or dysentery patients for instance and in tents this is only possible with nets. In the same way the disposal of the excreta is very important and all field hospitals use incinerators.

A special problem arises in the case of bodies of men moving. I believe that it is better in these cases to have no trench latrines, but to mark off a space of clean and hard ground and use that. The heat and dryness is such that flies cannot breed in the material

which desiccates at once. This goes against the sanitary expert's ideas but I believe it to be sound in all cases where the moving body is not going to stay more than three days.

These are the methods recommended and the three important ones are—

(1) Disposal of fly-breeding material.

(2) Fly poisoning.

(3) Fly spraying in trenches and hospitals.

It was obvious that to carry these out there should be a special subordinate officer attached to each large camp and to each division. He would naturally be under the orders of the Sanitary Officer but his special business would be flies. He would inspect the whole of the camp or the trenches occupied by his division, hunt out fly-breeding material, report cases of bad sanitation, see that latrines are oiled. He would be in charge of the fly poisoning, he would show men how to use sprayers and organize a gang to systematically slaughter flies with sprayers.

Such work is best done by men used to spraying and similar operations. Eight were required for the different places in Mesopotamia and I proposed going to Pusa for them, taking volunteers from the Imperial Pathological Entomologist's Section, as flies have been their business for years, and also from other sections, or from Provincial Departments if necessary.

Captain C. F. C. Beeson, Imperial Forest Zoologist, who was with me in Mesopotamia, remained there and would be in charge of these men and the whole work.

This proposal was accepted and I returned to India to organize supplies of arsenic, sprayers, etc., and to get eight men. The selected men are shown in the photograph which accompanies this article. They left Pusa on Wednesday, July 5th, for Bombay whence they proceeded to Basrah and Amarah. They were recruited from the entomological and mycological sections with one from the veterinary staff. They have rank as Indian Warrant Officers according to their pay and will be on duty in Mesopotamia probably till October. In the first place they join Captain Beeson to get experience of military conditions and then they will be posted out.

PLATE

The Agricultural and the Forest Research Institutes are to be congratulated on supplying the officers and staff for this work. No one anticipated that the work of the entomological sections would be of vital use in this war, and it is a satisfaction that the work done years ago in the Imperial Department has been of direct use and that the men and methods can be supplied for the present campaign. Their work will be very much appreciated in Mesopotamia and we hope all will return well with a successful piece of work well done.

AGRICULTURAL EDUCATION.

BY

WYNNE SAYER, B.A.,

Assistant to the Agricultural Adviser to the Government of India.

I. Introduction.

On the subject of agricultural education much has been said, many methods put forward and as many condemned, and a great deal of the discussion has been at a loose end. A partial acquaintance with a great many different systems and methods used and employed in the furtherance of agricultural education in the United States of America, Japan, Germany, England, etc., will suffice to show that the subject is a complex one requiring close consideration.

An examination of the different methods employed in different countries leaves one with a definite substratum of general principles which we may try to adapt to our local conditions. The first efforts will of necessity be largely experimental, but from the experience thus gained we can go on making changes in our system as they are proved necessary ; we have therefore to learn a lot before we can hope to arrive at any semblance of finality in our system of agricultural education, and this should be taken for granted by all parties concerned. As things stand at present we have three classes of people to educate, each of whom, in his own way, influences agriculture :—

First—The ryot, on his own land. He represents present agriculture in the active sense.

Second—His children who represent the active agriculture of the future, both workers and teachers.

Third—The landowning class, whose influence on agriculture is of the greatest value when properly applied and whose sympathy and interest can assist in the propagation of sound agricultural practices all over India.

These three classes linked in a proper appreciation of improved agriculture and its possibilities could create a new India and they wait on agricultural education to show them the way.

II. Development of English Education in this Country.

It will be well to take a cursory glance at the development of general education in this country before proceeding to the question of agricultural education, as it will enable us to better understand what effect it has had in the community and how it has affected agriculture. It was after Lord Macaulay's famous Minute of 1835 that the Government of India definitely decided in favour of English education. Education on Western lines was in fact becoming necessary as there was a growing demand for it. Another forcible reason was that as Government was settling down to administer and consolidate its possessions in India it required public servants with a knowledge of English to help its European officers in carrying on the work, getting into touch with, and making its intentions known to, the people.

The Universities of Bombay, Madras, and Calcutta were established in 1857, the Universities of the Punjab and Allahabad being founded in 1882 and 1887 respectively. As science was not so well advanced in those days, the education in India promoted by these Universities came to be more literary than scientific.

The English system of administration with its regular supervision of every detail and its foresight required a larger number of subordinate agents than was required in previous indigenous administrations.

Indian administrations in many cases under-paid their staff and winked at their recouping themselves—the natural result of under-payment.

The British system *gives* what is considered to be *sufficient* pay to remove any necessity for corruption. Thus those who received an English education got a large increase of pay compared with what they were used to under Indian administrations.

This acted as a great stimulus to Indians to seek an English education. It was regarded as a royal road to fortune and rightly so.

There was also a great demand for lawyers and pleaders consequent upon the fact that it was necessary to reduce the chaotic condition of the Indian administration, notably as regards land tenure and ownership to a definite legal status.

Further the opening of railways and the establishing of cotton mills and other industries provided employment for those who were only half-educated, or rather not up to the standard required for Government service and the law.

Thus the stream steadily began to flow in one direction and the effect spread to the remotest corners of the land and having saturated the minds of all and sundry it became a fixed belief. Hence there is stamped on the life of India one great goal, an English education followed by a Government billet.

There was an idea that the educated class would disseminate what is best in Western literature and science to their more backward brothers through the medium of the vernaculars, but this pious wish has more or less fallen flat.

Railways, irrigation works, Public Works Department, and factories have provided employment for numerous artisans, and from this the idea has grown up in a large section of the literary and agricultural classes that to stop in your village means starvation unless you have a large holding.

All this was brought about by a condition of things which could only be a transitory one based as it was purely on an artificial demand.

The tide still sets the same way, but the opportunities are now far fewer. The craving for education remains the same, and probably always will remain, but it is high time to see what we can do to divert it into more productive channels. It was towards the

end of the nineteenth century that the Indian Government began to think that all branches of education required careful review, and the Universities Commission immediately followed. Since then Government has leaned towards an education less literary and more practical, and in many Universities the courses have been altered to keep that end in view.

III. Agricultural Colleges.

It will thus be seen that the craving for literary education exists in the literate classes and in the more influential and higher agricultural classes. It is these classes who are ready to take advantage of scientific education in agriculture.

It was at first thought that no higher agricultural education would be necessary beyond such as would enable those who had received the two years' course in agricultural schools to make efficient subordinates under expert officers and to make those who did not enter Government service into better farmers.

Agricultural colleges of the advanced type we have at present in India came with the development of the Agricultural Department, the idea being that as agriculture is the backbone of Indian prosperity we cannot give too much agricultural education in this country; while therefore preference was to be given to boys who were brought up amidst agricultural surroundings; yet these colleges were to be open to such boys of the non-cultivating classes as might have a leaning towards agriculture. In the initial stages in order to attract students for these colleges Mr. Mollison, Inspector-General of Agriculture in India, was in favour of putting a leavening of agriculturally trained men into the Revenue Department on the ground that it is the subordinates of the Revenue Department who really see the agriculture of the land and who on account of their knowledge of the economic condition of cultivators can help forward the work of the Agricultural Department—a thoroughly sound view for many reasons which might well have been developed.

With regard to agricultural colleges at the present time it is as well to make one point clear which is apparently misunderstood

in some quarters that they are not intended merely to supply subordinates for the Agricultural Department, but to provide a liberal and scientific education in agriculture for those who either aim at higher appointments in the Agricultural Department or desire to take up higher studies and research work in agriculture for their own sake. In many European countries there is an agricultural faculty on the lines of other faculties in the Universities, giving liberal scientific education in agriculture and sciences allied thereto and training men for research work. In these no training in actual agricultural operations is given as the object is to turn out specialists fitted to carry on independent investigations. These faculties provide liberal scientific education in agriculture and thus attract the very best talent. **We think that in India also for the general widening of agricultural education affiliation to a University is desirable.** So long as agricultural colleges are not affiliated to a University they will not attract boys from the higher classes of Indian society connected with the land. These classes require a true collegiate education centring round agriculture, not mere manual training in the details of each agricultural practice. When these facilities are provided a fair number from these classes will be forthcoming, and the men thus trained will take their places as leaders of rural society with a thorough knowledge of what to aim at in the development of their estates. The strength of English agriculture lies in the fact that practically every land-owning Englishman has a knowledge of farming and stock-breeding—it is part of his life; *noblesse oblige* is the reason for it and the fact is recognized from the King downwards. Thus it can be seen that this class furnishes the country with a set of pioneers and influential supporters in agricultural improvement; and India wants a similar class. It is unnecessary to lay down that they should go through the same courses as those intended for the subordinates of Agricultural Department. What is wanted is to enlist their sympathies by giving them an insight into the subject and to make them able to realize the value of research and experiment; to make them see that to better the condition of their ryots is to their own advantage as well; to turn them from supercilious onlookers into sympathetic

co-adjutors of the Department; and for this it is necessary to create a strong faculty of agriculture at the University. One agricultural college affiliated to a University will meet the needs of Peninsular, and another Northern, India: for the class of men they are intended for will not require a college at their gates. They will go to the two colleges in the same way as land-owning England goes to Oxford and Cambridge. The rest of the colleges might be turned into agricultural high schools of the type prevailing in America, or agricultural schools in Germany or Switzerland and will cater for the needs of the Agricultural Department in providing recruits for subordinate posts.

IV. Education of grown-up Farmers.

The provision of agricultural colleges does not complete the scheme. As the cultivators are mostly illiterate they do not value a scientific education and in order to make them value this for their sons we have to show them what agriculture on improved lines can do in the amelioration of their material condition, *i.e.*, we must convince the father in the only way in which he can be thoroughly convinced, *i.e.*, by practical demonstration. Demonstrations should be given on Government farms, at the cultivators' own homes, or at any convenient place, together with short courses on special subjects and it is here that the subordinates of the Revenue Department if they had an agricultural training could help best. So long as the agricultural classes are in the backward condition they are now, demonstration must go to them. They cannot be expected to spend time or money to any extent coming to it.

In India the system of caste has given the cultivator centuries of traditional experience behind his back. He knows to an inch what he can do with the limited amount he has to hand. We have therefore to be careful not to disturb this economic balance by an improvement which may be excellent but which would not work here, and it is the study of this economic balance both in this and in other greater and wider directions which is becoming a grave necessity, and which I hope to deal with later.

We are constantly reminded forcibly by print and illustration of the wonderful improvements brought about in other countries but this should be remembered that the introduction of improvements in Australia, Canada, and the United States is brought by capital. People who have little or no experience comparatively of the land they own, will always imagine a new thing to be much better than it is. They will risk more. They are new men in a new land. They have experienced few of the set-backs incidental to agriculture, and their hopes are correspondingly higher. Here in India it requires a strong man to introduce an improvement; it has to be a very strongly markéd improvement if it is to be adopted by the ryot; India has a rooted conservatism which cannot be realized by the countries like the above.

Again it is useless to blame the Indian farmer for adopting a policy of backing two horses in his farming. He grows two crops on one field; why? because he is not sure of the rains. Whatever happens he wins out on one and saves himself from starvation. The net yield of either crop, which is of course small, may be held up as a scandal by an expert who has never been in danger of starvation—but it is rare to find gross carelessness or gross neglect. The lives of too many depend on that crop—and that is the reason for the margin of safety so easy to refer to as wasted opportunity but so difficult to do without in the present day.

This then is the position. We can hardly teach the ryot his own job if we are limited to his circumstances. I venture to say no one can, but let me not be misunderstood. Agricultural Departments can open the gate to greater things by virtue of money. All improvements require capital. It is no use telling the ryot to do his own experiments—he cannot; his margin is too small but the Agricultural Department can do this by finding the capital for them. It is possible to bring an improvement within his reach when arrangements have been made for financing him so that he can safely take it up. To educate a man at an agricultural college and to send him back to work on a farm with no capital is useless. It may sound well to say he has been educated, but the effects will be nil.

The application of scientific knowledge to Indian agriculture opens out a vast field for increasing the out-turn of crops in India, *e.g.*, the yield of rice per acre in India is only about $\frac{1}{5}$ of that in Spain, that of wheat is about $\frac{1}{3}$ of the average out-turn in England, and it is only the Agricultural Department which has the capital, science, and skill that can undertake experiments for increasing the yield. A long series of tests is necessary before any definite agricultural improvement can be recommended for adoption, for jumping at conclusions to make a show and a splash in a country like India is fatal; time here is no object, to-morrow is also a day. Sooner or later the part that has been missed—slurred over, written away will be found out and a deep-rooted mistrust will oust the slow-grown confidence in the Department as a whole.

Now turning to the subject of demonstration as a method of education, while the evolution of new types and the replacing of inferior kinds by superior varieties are very promising lines of agricultural improvement in this country they will take time. We also realize that research must precede demonstration, but in the unequal agricultural progress of the cultivating classes in India there are many good practices which are known in one part and not in others. These require to be brought to the notice of more backward tracts. It will thus be seen that the greatest and the most immediately remunerative work lying ready to hand is not the introduction of some scheme requiring extensive, expensive machinery from abroad. It is the quiet, systematic transfer of the best agricultural practices from one province to another, from one district to another. The transplantation of rice seedlings known for years, nay, ages in many parts, was unknown in Chhattisgarh and there now ranks as the greatest improvement and rightly so. And it is here that the Agricultural Department has done wonders at a trifling cost, to quote but one instance. Such improvements impress the ryots, create in them an enthusiasm for progressive farming, and make them see the wisdom of receiving a training which enables a man with a wider outlook to pick the brains of others and apply them to his own use; for it is through this experimental avenue that an increase of revenue will come to ryots and the State, and it

should be obvious that **this is the most paying line of policy in laying the foundation for the demand for real agricultural education which will follow directly the ryot is convinced that there is something in it.**

As already pointed out above, agricultural improvements in most cases require capital. What is therefore wanted along with the spread of improvements is an effective method of obtaining capital, through as few intermediaries as possible, at a reasonable rate, and it is here that co-operative societies, though only in their infancy, can do most good. The passage of the money from lender to borrower *must* be simplified.

Agricultural seasons wait for no one, and to find a man, who has applied for a loan to get good seed, forced to fall back on cheap inferior stuff, owing to inability to get his loan in time, is what we want to avoid. The man who lends money on to the land must lend it when the land wants it, for the land is a bank whose doors are only open for deposits on really favourable terms for a very short time and this cannot be too strongly emphasized.

In the drier parts of India money lent to dig a well does more than this: the mere digging of it not only ensures the rains crop against possible failure, but it also encourages intensive farming and prolongs the cultivating seasons throughout the year and provides the ryot with employment for himself and family all the year round, weans him from idleness and litigation by making him live on his land. Where else does the digging of a well do all this? Certainly in no town. It is for reasons like this that the co-operative societies want more money and it should be made available to them. Every pie spent thus by a primary society will return a hundred-fold by increasing prosperity and stabilising the revenue. The successful working of these societies will raise the moral tone of the cultivators, and this in itself will produce the better, steadier, more prosperous class which it is the aim of every country to produce.

V. Education of the Cultivators' Sons.

General observations.

What is the aim of education? It is to make the nation more fitted to take its place as a nation among other nations, to hold its

own in the great economic struggles of the future, and in this coming struggle the dignity of labour will bear the brunt. Education should aim at producing a future race each better than his father at the family job and not necessarily a renegade from his ancestral profession. The present education is given totally irrespective of the parentage and of the future of the individuals : can it be wondered, then, that it all too often fails ?

While it may be admitted that some knowledge of the three R's is necessary to every man in the present stage of the evolution of the world, yet after this, specialization should commence as soon as possible, based on the needs of the man. Specialists at their best should be improvers of their fathers' work carrying on the family traditions ; one cannot emphasize too highly the fact that the national prosperity depends on the skill of its people, its varied development, and not on the super-literary education of a minority. And any education, which does not go deep enough to improve the man's chances of making a living to the good of the country, is no use. A highly educated class for whose labour there is no demand can only be parasitic on the country which educated it.

Education in rural schools.

We now come to examine education as provided in rura schools.

Many people with vague notions of agricultural education often advocate that in village primary schools the Education Department should begin to teach agriculture. Let us examine what this means. In primary vernacular schools boys have to learn reading, writing, and the doing of ordinary sums in arithmetic. Nothing more can be added at that age to their syllabus. It is sometimes said while we cannot teach agriculture we should teach agricultural principles ; but it is only developed intelligence that can follow the abstract—the children should go from concrete to abstract and from practical to theoretical. To cram them with these principles without their understanding them will only produce harmful effects, which will be very hard to

obliterate at school or college. What is required at primary schools is that the teaching should have more relation to the environment of the children. Text-books suitable for urban primary schools are not suitable for village schools and at present they are common. Hence children taught in village schools become rapidly divorced from their fathers' profession. In arithmetic also—teachers should deal with sums relating to payment of rent, real measurements of fields, calculation of fields' produce, etc., all things which will prove useful later on. But the difficulty is that in a large number of cases the scholars in rural primary schools are drawn from non-agricultural classes. Further, the primary schools are part of an educational ladder by which the clever boy whether from town or country can go up to the anglo-vernacular school and perhaps to a college. A different syllabus for boys in the rural school will handicap them in this respect. It will thus be seen that, while direct teaching of agriculture is to be deprecated, the giving of an agricultural tinge to the education imparted in the higher classes of these rural schools is a great desideratum, especially for those children who are not going up to the anglo-vernacular schools, and in this connection the value of nature study and school gardening cannot be over-estimated. It is the teachers who can, even with existing text-books, make the instruction suitable to the requirements of rural children. But this is where the teachers fail in a large number of cases—they miss the real point and the essential part: to sit in a class room and make remarks—is not what is needed. To go out and show the class what to observe is really what is wanted. Later on we find students lacking in observation and practical initiative and in manual skill; why? because throughout their whole training book-work has ranked highest, and it is only when they come out into the world they find that the position is reversed —much to their detriment. All over the world the cry is for skilled labour and always will be, and the man who is master of a trade is always sure of his living. It is an age of mechanism, a fact which India has not yet grasped.

Year by year the farmer becomes more of an engineer, and all trades tend to inter-connect to their mutual advantage. A big

farmer with one son trained as a mechanic and one as an agriculturist is both master of his land and his implements; with the rise in wages more labour-saving implements are introduced and the rise in the price of cattle helps as well. There can be no set-back to the use of agricultural machinery now; it has shown the world what it is capable of doing and the world, after one great gasp of surprise, is hastening to take advantage of the lesson.

It is important not to stifle the would-be mechanician in early life—we all remember the fate of the boy with the mechanical mind in our public schools. He used to be regarded as a social pariah, a creature of wild mind and wilder pursuits. Now he has ousted the classical people from pride of place throughout the land and what has happened in England should guide India; for the present war has given England an enforced mechanical education, the use of which will never be forgotten by the nation—for it is not a knowledge of the classics and certainly not a knowledge of law which is beating the German.

While we note the fact that manual training is provided in some of the schools in India we wish that it may be developed more and more, not as a fashionable fad, but as a prime necessity. It is often asked why it is that in spite of India's enormous cheap labour market and its proximity to the supplies of raw material, India cannot fairly compete with other western countries. The answer is that unskilled labour though nominally cheap yet in these days of machinery is ultimately dearer. Skilled labour has to be imported at a fabulous price, for the combination of unskilled labour and expensive machinery is the most expensive thing on earth. Any one doubting this need only give a cooly a mowing machine to work for a day. The cooly costs far less than a skilled man, but the repair bill of the machine swallows up the difference and the machine wears out far quicker.

Special Vernacular Agricultural Schools.

We now come to a consideration of the question what provision should be made for the sons of agriculturists who, after completing their vernacular course, are not going up for English education, but

wish to gain more useful general knowledge coupled with some instruction in agriculture. We think that in the case of these the provision of vernacular agricultural schools on the lines of that at Loni is most desirable. The boys at this age will be able to understand why certain results follow from certain causes. For the information of those of our readers who are unacquainted with this interesting experiment initiated by the Bombay Department of Agriculture we may say that the courses at Loni are of two years for boys who have passed at least the 4th Vernacular Standard, aged 13—18, 3 to 4 hours' are devoted to general education, while a similar number of hours work is done in the field. The whole of the cultivation is done by the boys and they all learn to make simple implements, the use and care of good steel implements as well as how to drive an oil engine which pumped water, bruised grain, etc. The teaching is entirely in the vernacular. As this was the first attempt of its kind board and tuition were provided free. The boys were mostly drawn from the sons of large cultivators with whom the Department was in touch though a considerable number of applicants were of the more literary class who were only admitted with great care. The boys trained at Loni have started real centres of interest in agricultural improvement on return to their own land. The success has been so gratifying that similar schools have been started in other divisions partly with Government money and partly with local subscriptions and endowments.

In starting such schools in different parts of India the exact age and educational qualifications for recruitment and the ratio between the general education and the technical education to be given at each school will have to be determined according to local conditions. But it would be well to bear in mind that practical training in each detailed piece of agricultural operations should not be considered as the only thing. What is required is to give them some knowledge of mechanical engineering and good general education with agriculture, so that the outlook of these boys may be widened and they may go away with an enthusiasm for their own calling and carry on their business in a really intelligent manner.

VI. CONCLUSION.

If a boy was made to work with his hands from the beginning he would appreciate the dignity of labour and his whole after-life would not be aimed at a position of *looking-on*. The aim is to assist a boy at his future work, not to divorce him to follow another calling.

The essential of most English engineers is the fact that they have been through the shops from the very beginning. I have known a man with a University degree who spent a month doing under-fitter's work in his father's Works. When India grasps the fact that to run a business successfully you must know the inner working of every step and detail, then we shall get captains of industry in other walks of life than money-lending and the law. Mere learning of science will not make a practical workman; it is the combination which is so strong.

Now is the time for India to make her effort. Her greatest asset is agriculture and the agriculture of the world was never so prosperous. Agricultural produce will rise in value after the war. to the benefit of India. Let her, therefore, take steps to put her chief industry on a better footing; better cultivation, better marketing arrangements, better financing of the rural population, a wider use of mechanical power is demanded. All the world is moving rapidly on the line of advance. And if India lags behind it will be a national calamity. Let her bestir herself and realize that the produce of the land is capable of a considerable amount of increase. This better state of things will be brought about by the education of the adult farmer and the rising generation who will farm when he has gone—in short by the education of India in a direction where best the talents of the nation may be fully and profitably employed to the benefit of all.

WHY ARE THE CULTIVATORS' OUT-TURNS OF WHEAT ON IRRIGATED LAND SMALL?

BY

W. ROBERTSON BROWN,

Agricultural Officer, North-West Frontier Province.

THIRTY-SIX maunds[1] per acre on two acres; twenty-eight maunds per acre on eight acres; twenty-five maunds per acre on thirty-two acres; twenty-two maunds per acre on eighteen acres; an average yield of about twenty-five maunds per acre over all these acres; these are the yields of wheat harvested at the Tarnab Agricultural Station this past May.

The average out-turn per acre on the 100,000 acres of irrigated wheat in the Peshawar District is less than twelve maunds per acre: is less in fact than half the average yield per acre over 60 acres at the Agricultural Station. Yet only 8 of the 60 acres received any manure; one-half of the area was irrigated once only; the remaining 30 acres received but two waterings; the rainfall during the period of growth was only 5·10 inches; harrowing and inter-cultivation were not practised; on three-quarters of the 60 acres wheat followed wheat; one ploughing with the Rajah, and two turnings with the country plough only were given to the land. In short, the Tarnab wheat would not appear to have received better cultivation than wheat in the neighbourhood.

Why, then, are the yields in the vicinity of Tarnab and those stated in the Season and Crop Report so very much less than the Agricultural Station out-turns?

The varieties grown at Tarnab are Pusa No. 4 and Federation, and these are noted yielders, but their superiority to local wheat in this respect will not nearly account for the out-turn of

[1] A maund = 82·12 lbs.

the Station being more than double that obtained by the cultivators.

To those who spend their lives with the cultivators on the land the enigma is made plain.

Firstly, it may be stated that the failure to produce high, or even fair, yields of wheat is rarely due to the cultivator's ignorance of good methods of growing the crop, or to the inefficiency of the implements employed in tillage, or even to the lack of a good yielding variety of wheat. These are simple reasons which readily occur to any one and are commonly assumed to account for India's poor out-turn of wheat per acre. The real causes are, however, more subtle, and less uncomplimentary to the Indian cultivator's intelligence than the above.

A large part of the cultivators' land yields two crops within the year, and actually realizes more money than bumper *ek-fasli* crops of 20 or more maunds per acre. By long experience each cultivator knows it is not safe to put all his eggs in one basket, and almost every one prefers moderate, upstanding crops of maize and wheat to fields of bountiful promise which stand in danger of disaster by wind and flood. This is the circumstance above all others that accounts for the disparity in the out-turn of wheat obtained at the Agricultural Stations and those recorded in the Season and Crop Reports.

There are numerous other conditions tending to reduce the cultivators' out-turns which should be considered but which are never stated in comparing Agricultural Station out-turns with those recorded in revenue reports. The wheat growers for example give at least 1/15th part of their crop to the harvesters in payment of their labour and probably each alternate year some wheat is lost on the threshing floor owing to bad weather and other causes.

Then holdings are small and the cultivators are poor; at times cereals follow cereals for some years, wheat following maize or *juar* with little rest or change to the land, and with scant manuring. Or if by chance the cultivators miss their turn of irrigation, sowing may harmfully be delayed, or a plague of weeds from a careless neighbour's field or an overgrown watercourse may choke their

wheat, when they are too busy, or may be too lazy to undertake weeding or to hire labour to perform the work.

Yet again and alas! many of the cultivators are in debt, and remain merely the unwilling servants of the *baniahs*, or almost equally unfortunate, they may be year to year tenants of the lease holders of extensive tracts, when lessees and tenants alike are bent on taking the utmost from the land at the minimum cost, regardless of the maintenance of fertility and cleanliness.

In examining the agriculture of a country-side in India, it is disappointing to find a large proportion of the crops adversely affected by one or more of the unfortunate conditions mentioned, and perusal of the Season and Crop Reports is very disappointing to the enquirer who is unacquainted with Indian agricultural conditions and practice.

It is perplexing to read that ten maunds per acre is the average out-turn on 1,000,000 acres of irrigated land, while in Agricultural Station Reports out-turns exceeding 30 maunds per acre are sometimes reported. Despite what has been stated in explanation of the cultivators' failure to produce good out-turns, and even admitting that Agricultural Station out-turns are sometimes estimated on quite small plots, the great disparity existing in the field and station yields is not yet clearly accounted for.

The enquiry may be pursued by comparing the treatment which produced 25 maunds per acre on an area of 60 acres at Tarnab, with the cultivation usually given to wheat in the vicinity.

Rotation and Tillage. The wheat at Tarnab was an *ek-fasli* crop, wheat following wheat on the greater part of the area. On the cultivators' land on the other hand, wheat is almost entirely a *do-fasli* crop, following maize, and the out-turns may therefore be about one-third less than the Tarnab *ek-fasli* yield of 25 maunds per acre. This practically means that the cultivators should harvest 16 maunds per acre from their *do-fasli* land and if the cultivators' out-turn is allowed to be 16 maunds per acre, there yet remains a deficiency to be accounted for to bring the cultivators' out-turn up to the Tarnab yield.

As wheat followed wheat at Tarnab, the land was turned over by the Rajah plough before 15th June. The cultivator's *do-fasli* land, on the other hand, could not be ploughed until 15th October, after maize was harvested. *Do-fasli* wheat is sown, in fact, within a few days only of the first ploughing of the land, and the cultivator's prospects of a good yield are here far poorer than at the Agricultural Station. But the cultivator's land probably produced a crop of maize, value Rs. 60 to Rs. 70, whilst the Tarnab wheat land was fallow and renewing fertility between July and October.

Irrigation. Tarnab has no advantage in this most important aid to wheat production, both the cultivator's wheat and the station crop being irrigated once or twice only.

Inter-cultivation. Again, Tarnab has no advantage, harrowing being impracticable on irrigated land, and hand-hoeing being too expensive and slow to undertake on 60 acres of wheat.

Weeding. The cultivators may lose somewhat in this direction, as they weed less thoroughly than at the station.

Protection. There are few cultivators' fields that are not damaged by browsing animals. At Tarnab no loss occurs in this direction.

Harvesting. The cultivators give 1/15th or more of their crop to the harvesters in payment of their labour. The station paid cash, and the final out-turn was therefore not reduced in weight by the harvesters.

Threshing. A steam thresher treated the Tarnab wheat a few days after it was cut, and loss of grain did not occur on the threshing floor. The cultivators, on the other hand, are very fortunate if they do not lose 1/20th of their crop during threshing.

Variety of wheat. Under equal conditions, Pusa No. 4 may be depended on to yield one maund per acre more than the local wheat.

Now the disparity in out-turn between the cultivator's yield and the station out-turn is nearly accounted for.

It has been shown that the cultivators lost weight of wheat approximately as follows :—

	Mds.	Seers.
(1) By practising *do fasli* cultivation	8	0
(2) By neglect of weeding	0	20
(3) By the ravages of browsing animals	0	20
(4) By paying harvesters in wheat	1	0
(5) By bad weather during threshing	0	20
(6) By the inferiority of their variety of wheat ..	1	0
Add	11	20
The cultivators' actual out-turn	12	
	23	20

If to the above are added the small shares paid to the blacksmith, the carpenter, the barber, the chaukidar, and the 1/10th part so faithfully given by many to the poor in the name of God, it will be found that under reasonably comparable conditions, the out-turns actually produced on irrigated land are not as pitiable as they are usually assumed to be. The losses stated at (1) to (6) are chiefly due to circumstances over which the cultivators have little control; on no account is loss caused by mere ignorance of good practice in the simple art of growing wheat and, above all, it should not be forgotten that the profits realized by the cultivators are no less than those obtained from the heavy *ek-fasli* station crops, and it is probably true that over a period of five years or longer, the balance of profit would be in favour of the cultivators and well designed *do-fasli* practice.

By pursuing clean, careful cultivation and growing an upstanding superior variety of wheat, the cultivators can improve their out-turns, but they will not be encouraged to do so by belittling their actual attainments and placing before them high agricultural station out-turns without due regard to the difficulties that prohibit them from attaining these yields.

THE INFLUENCE OF THE WEATHER ON THE YIELD OF WHEAT.

BY

ALBERT HOWARD, C.I.E., M.A.,

Imperial Economic Botanist, Pusa.

1. Introduction.

THAT a general connection exists between the weather and the yield of crops is well known. This is referred to every year when the annual accounts of the Indian Empire come up for discussion. On these occasions, the Finance Member of Council often says that the Budget is little more than a gamble in rain. Sometimes, however, the matter is gone into in greater detail and attempts are made to treat the subject from the statistical standpoint and to apply mathematics thereto. The results obtained can hardly be said to be convincing. Apart from the scepticism with which many people regard attempts to prove a case by means of numbers, a little consideration shows that the subject is one to which, in the present state of knowledge, a mathematical treatment can hardly with confidence be applied.

The various meteorological factors like rainfall which are included in the weather are definite things and can be measured with reasonable accuracy both as regards amount and distribution. A wheat crop, on the other hand, cannot be treated in quite the same way. It is an assemblage of living machines which, by means of their chlorophyll corpuscles, are able to utilize the energy of sunlight in building up complex food substances from simpler materials such as mineral salts, water and carbon dioxide. There

is also an orderly development from the seedling stage to the mature crop and, during the whole growth period, the plants are competing with each other and are reacting to the various growth conditions—moisture, temperature, the supply of oxygen and mineral food materials in the soil, and the degree of moisture and movement in the atmosphere. Not only does the crop react to its surroundings but also the extent of this reaction depends on the stage of development reached. In addition, the various growth factors influence each other to a marked degree. For example, the rainfall not only affects the crop directly but also indirectly by altering the temperature of the air and of the soil, the atmospheric humidity and often the gaseous interchange between the soil and the air. Before we can even apply statistical methods to the connection between yield and a single weather factor such as rainfall, it is clear we must have some means of weighting the figures with reasonable accuracy. The effect of rainfall will vary with its amount, with its distribution, with the stage of development of the crop and with the character of the preceding monsoon. It will also influence, according to circumstances, the other growth factors such as temperature, soil aeration, humidity and air movement. As no two seasons in India are ever alike, it is obvious that we are dealing with too many mutually interacting variables to be able to define in mathematical terms the effect of any particular fall of rain. When we are dealing with the general effect of the weather as a whole on yield, the difficulties naturally increase with the increase in the number of factors. The most important matter connected with a wheat crop is naturally the yield of grain. This is the resultant of all the conditions of growth of which the weather is only one. It is clearly the merest speculation to attempt to deal statistically with the effect of any one factor on the system as a whole and it would appear that the subject from its nature is one to which mathematical treatment cannot possibly be applied.

There is, however, an alternative method of dealing with such questions. The growing of a wheat crop is after all a matter of applied physiology. The choice of soil, the preliminary cultivation

and the supply of air and water to the soil can best be looked upon as improvements in the conditions of growth, all of which are greatly modified by the weather.

During the last eleven years, the writer has obtained a considerable amount of practical experience in the cultivation of wheat and of the effect of the various conditions of growth, including the weather, on the yield. In addition to the rainfall, the soil temperature appears to be a most important factor while the aeration of the soil seems to affect the plant more than anything else. The results of numerous observations on these questions are dealt with in the present paper.

2. The Conditions of Growth of a Wheat Crop.

The soil conditions under which wheat thrives best have been known to agriculturists since remote antiquity and are referred to in the writings of such Roman authors as Cato and Varro. Modern investigations have naturally added to the knowledge possessed by the ancients but the cardinal importance of thorough cultivation for wheat and a soil of the proper texture and content of organic matter have been known and acted upon since the dawn of history. Provided the soil admits of copious root development and is fairly retentive of moisture, the amount of rainfall or irrigation water necessary for wheat is not considerable. A fair crop can be ripened with remarkably little moisture. Good soil aeration, by means of which the soil organisms and the roots of the wheat plant can obtain abundant oxygen and, at the same time, get rid of the carbon dioxide produced in the soil is quite as important as the water supply. Particularly is this the case during the ripening period when any interference with the aeration of the soil prevents maturation and also tends to induce rust attacks. The temperature of the soil is another important growth factor. Wheat, as is well known, is a crop of the temperate regions and is not cultivated in the hottest areas of the globe. In semi-tropical countries like India, it is only grown in the cold season and experience proves that the sowing time of wheat is largely regulated by the soil temperature.

3. The Influence of Rainfall and Temperature on Growth.

Rainfall. The climatic factors which have the greatest effect on the yield of wheat in India are unquestionably the amount and distribution of the rainfall. Within limits, the distribution of the rain is more important than its amount. Provided the subsoil is fairly moist, late September and early October rains are the most significant as they not only supply moisture for the final preparations and for germination but also cool the seed-bed sufficiently for the young crop to thrive. On the other hand, a heavy monsoon ending in late August or early September which is not followed by the sowing rains is generally unfavourable for wheat in alluvial tracts like Bihar and Oudh, and in black soil areas like Bundelkhand and the Central Provinces. In the former case in such seasons, the soil is almost certain to be on the warm side at sowing time, while in the latter there may be insufficient surface moisture for germination.

After sowing is completed, the first rains, known as the Christmas rains, generally fall towards the end of December or during January. These are, on the whole, light and well-distributed and, as is well known, originate from depressions which pass over India from the direction of Persia and Mesopotamia. It is rare for rain to fall during November and early December. The Christmas rains are exceedingly beneficial to the wheat crop. They not only moisten the soil but check any tendency for the ground to get too warm. Generally speaking, they serve definitely to establish the cold weather which is so important for the well-being of *rabi* crops. These winter rains, however, are often delayed and may not appear till late in February or even in March when their influence on the yield of the wheat crop is small and may even be distinctly harmful, particularly when heavy falls occur after the wheat is in ear. Except in the extreme North-West, such rain is too late to exercise its full effect on the growth while the formation of surface crusts interferes with the aeration of the soil and tends to help in producing those conditions which bring on rust attacks. Rain and moist weather when the crop is ripe easily set up sprouting in the ear as the temperature is usually high at this period. Showers

during the threshing period cause a little damage from a similar cause, but the people are very clever in protecting their grain heaps and it is rare to find that the moisture penetrates more than an inch or two. In estimating the effect of the rainfall on a wheat crop the distribution rather than the total amount is important. Late September and early October falls are the most valuable of all while early, well-distributed Christmas rains, not exceeding two inches in amount, follow next in order. Late rains, if heavy and long-continued, are decidedly harmful by preventing maturation and by producing rust. A heavy monsoon ceasing early leaves the soil and subsoil too hot for wheat in the warmer wheat tracts of the country.

Temperature. After the distribution of the rainfall, the soil temperature is perhaps the next most important meteorological factor in the growth of Indian wheat. If sown too early before the soil and subsoil have cooled down sufficiently, the wheat seedlings wither and are eaten up by white ants (Termites).[1] When sown at the proper time, however, when the soil and subsoil have cooled sufficiently, the seedlings thrive and white ants do not trouble the crop. Experience shows that the dying off of the young crop is particularly widespread in Bihar and Oudh in years when the total monsoon rainfall is large, when the rains cease early and when the sowing rains (*hathia*) fail. In such seasons, the soil is charged with large quantities of warm water and cooling is slow on account of the mass of water involved and the necessity of keeping the soil closed down to prevent too much evaporation. Such soil conditions occurred in Bihar in 1914 and again in 1915, and whenever they do it is interesting to note that the *ryots* always sow too early and often lose their wheat entirely particularly on the heavier lands which hold the most moisture and presumably cool down more slowly than the drier, higher-lying fields. The remedy for this

[1] It is an interesting fact that in such cases the wheat always germinates well and for a few days shows great promise. This is probably due to the temporary cooling of the surface soil by the evaporation of moisture during the final preparation for sowing. As soon, however, as the roots reach the warmer subsoil, decay sets in and the seedlings begin to wither. At this stage, they offer attractions to white ants which seem to be the consequence rather than the cause of the damage to wheat at this period.

trouble in such seasons in North Bihar is to postpone sowing till the end of October and to cool the soil by evaporation by allowing the furrows to remain open to the sun and air for two or three days according to the amount of moisture present. When this is done, there is much less trouble on account of a hot seed-bed and white ants do little or no damage.

So far, little has been done in tracing the connection between the temperature of the soil in the plains at sowing time and the distribution of the rainfall. The subject is being investigated in the Botanical Section at Pusa and the results will be published in due course. It is fortunate, however, that one series of Bihar soil temperatures is on record which bear on this point. These were taken by Mr. H. M. Leake at Pemberandah during the period March 10th 1903, to March 3rd 1904, and are published in detail in the account of the research work on indigo carried out at Dalsing Serai during 1903 and 1904 by Messrs. Bloxam and Leake. These observations were made thrice daily at 8 A.M., 1 or 2 P.M. and at sunset. The spot selected was the middle of an exposed area of high, light land which was kept free from weeds. The weekly average temperatures at a depth of four inches at mid-day (1 to 2 P.M.) are given in the following table in which the rainfall is also recorded :—

TABLE I.

Soil temperatures and rainfall at Pemberandah.

Period	Average temp. (4" deep at 1 or 2 P.M., in degrees Centigrade)	Rainfall (in inches)
Sep. 2— 8	30·4	1·4
9—15	30·5	1·0
16—22	30·4	0·1
23—29	29·7	0·6
30—Oct. 6	29·1	2·6 Including 1·6 inches on Oct. 6th.
Oct 7—13	28·0	0·8
14—20	28·0	
21—27	24·9	
28—Nov. 3	22·9	
Nov. 4—10	21·3	
11—17	19·8	
18—24	20·0	
25—Dec. 1	18·7	
Dec. 2— 8	16·5	
9—15	15·8	
16—22	14·4	
23—29	15·2	
30—31	13·1	

It will be observed that there is a rapid fall in the weekly averages after October 20th and that during the succeeding fortnight the temperature fell more than five degrees. The daily temperatures (at a depth of 4 inches and at 1 or 2 P.M.) during this period are given in Table II.

TABLE II.

Daily temperature readings at Pemberandah after the sowing rains.

Date	Temperature (Centigrade)	
Oct. 16	29·5	All readings taken at 4″ at 1 to 2 P.M.
17	28·7	
18	28	
19	26	
20	26	
21	26	
22	26	
23	25	
24	24·7	
25	24·5	
26	24·5	
27	24	
28	23·5	
29	23	
30	23	
31	22	
Nov. 1	...	
2	23·5	
3	22·5	

The fall in temperature from the middle to the end of October is fairly continuous and amounts to 7°·5 C.

Wheat sown in such a season on October 16th would probably have died out while sowings made during the last week of the month would have developed rapidly without a check. In such years when the *hathia* is received, there is often a marked change in the character of the weather about October 20th, the air feels fresher and westerly breezes set in. When these have been blowing for a week or so and the cold season appears to be well established, wheat can be sown without risk. The subject, however, needs more detailed study and the wind velocity, wind direction as well as the humidity of the air should be recorded. The temperature observations on low-lying fields containing much moisture should also be compared with those simultaneously obtained on high-lying, lighter and drier land. These meteorological observations should then be correlated with the extent of root-development and

with the general above-ground growth of the wheat crop. It is certain that, when the seed-bed remains on the warm side, the root-development is poor and the plants begin to shoot prematurely. This tendency is perhaps even more pronounced in the case of *sarson* (*Brassica campestris*) and yellow flowered tobacco (*Nicotiana rustica*) than in the case of wheat. Either of these two crops could be used as living thermometers whose indications would supplement those of the ordinary instrument.

4. Some Practical Applications.

There are at least two directions in which the ideas in this paper can be made use of for practical ends. One relates to the duty of irrigation water in the warmer wheat tracts of India and the other to the improvement of crop forecasts.

Irrigation. The provision of moisture for crops is considered to be the object of all schemes of irrigation. It is more than probable, however, that artificial watering serves another purpose in the case of *rabi* crops, namely, the cooling of the soil to enable vigorous root-development to take place. This being so, the possibilities of the extended use of irrigation water in tracts like South Bihar, the Central Provinces and Bundelkhand ought to be re-considered. It might pay to construct tanks (reservoirs) in these areas solely for the purpose of watering land once in October prior to sowing. This irrigation would cool the land, would give plenty of moisture for germination which, under judicious management, would carry the crop through to harvest. In the case of well irrigation in certain parts of Oudh, there appears to be, on the stiffer soils, an opening for wheat growing with a single watering applied in November followed by the sowing of a rapidly maturing wheat like Pusa 4.

Crop Forecasts. Although the methods adopted in the preparation of crop forecasts in India are a great advance on those previously in use, nevertheless the application of physiological ideas would lead to a still higher degree of accuracy. In framing the first wheat forecast, the distribution of rainfall after the middle of September, the mean air temperature during October and the direction of the wind in the Gangetic plain should receive particular

attention. The root-development and the foundation, as it were, of the crop depend on these factors. In the second forecast, the distribution of the winter rains and the general air temperatures during December and January are significant. Light, well-distributed rainfall, low temperatures and clear, bright weather during the vegetative period are the factors on which the future yield depends. Long spells of abnormal hot weather during this phase or very heavy rains are sure to be harmful. In the final forecast, two things are important—the rainfall and temperature during the ripening period and the manner in which the ears ripen. Anything more than the lightest rainfall during the period of maturation is harmful and temperatures above the average are inimical to a high yield. The appearance of the ears from the time the grain is half ripe till the harvest is perhaps more important than any other indication in estimating the final yield. For a full crop there is a characteristic development in the shape of the spikelets and in the colour of the straw and ears which cannot be mistaken. When half ripe, the spikelets bulge considerably due to the swelling of the middle grain and the ear assumes an uneven, turgid condition. The straw and chaff have a bright healthy appearance which is continued till the crop is ripe. The contrast between this condition and the look of a low-yielding crop is very marked. In the latter case, the ears remain narrow, the spikelets are regular, the ears and straw appear lifeless and the full colour of the chaff is not developed. The range between these two conditions is, of course, great and amounts to at least five maunds an acre. In the United Provinces in 1915, when the conditions for ripening were exceedingly unfavourable and the forecasts of outturn proved to be optimistic, the yield would have been reduced by five maunds to the acre had the appearance of the ripening ears been taken into account. The 1916 crops in parts of Bihar, on the other hand, should have been increased an equal amount. A ripening factor, which can best be judged by the officers of the Agricultural Department and which need only be determined in each of the chief wheat-growing tracts of a Province would be most useful in correcting the ordinary estimates of area and yield sent in by the Revenue authorities.

SUGARCANE CULTIVATION IN NON-TROPICAL PARTS OF INDIA.

BY

WYNNE SAYER, B.A.,

Assistant to the Agricultural Adviser to the Government of India.

We are led to write this article in response to the following criticism published in *Commerce* of Calcutta, dated 4th May, 1916 :—

"The wonderful progress made in sugar-beet cultivation in Europe and cane cultivation in Hawaii, Mauritius, Java, Cuba, and Louisiana, show what science, higher education, and common sense can do for an industry. We in India are still waiting for the Agricultural Department to show us if any possible advantage can be derived from the experimental work carried on by the officials in their effort to solve what seems to be an almost hopeless task. The possibility of improving sugarcane cultivation in Bombay, the Central Provinces, Bengal, Assam, and South India we realize : but what the Agricultural Department expects to do for cane in Bihar, the United Provinces, and the Punjab is beyond our comprehension. We are led to these reflections because we recognize the scope for improving cane grown within the sugar belt and we therefore see no necessity for the department to waste their energy on this cultivation in the United Provinces and the Punjab, where cane cannot be grown satisfactorily owing to adverse climatic and soil conditions. That the climate in the United Provinces and the Punjab is not suitable to sugarcane is a recognized fact ; and consequently, we cannot include these in the sugar belt of India. Parts of Bengal, Assam, the Central Provinces, Bombay, and Madras are within the sugar belt we know ; that the soil and climate in Bihar is not suitable for cane we also know. Why does the Agricultural Department then employ time and labour on research work for securing

cold-resisting canes with early maturing tendencies, when there is an ample scope for expansion and improvement in provinces within the sugar belt? Although plants can to a certain extent adapt themselves and be domesticated outside their climatic belt the fact remains that their cultivation never really becomes a commercia success, but will always remain an uncertain proposition. With sugarcane this has been borne out time and again and for additional proof we need only compare the yield obtained in the provinces of India such as Bombay, the Central Provinces, and Bengal against Bihar and the United Provinces. In Queensland the cane is grown with uncertain prospects as far south as Nambour, 60 miles north of Brisbane. Cane is grown to a small extent in New South Wales but not successfully. In the Southern States of the United States of America cane has been and still is grown on a small scale as far north as Georgia, Mississippi and Texas. In the last State they even tried to grow cane in the 'Pan Handle' of Texas; but these attempts have not been successful and yet people persist in its cultivation. We could quote a number of other countries where certain climatic and soil conditions have created crop belts, all attempts to improve the types of so-called domesticated crops having failed. These matters could possibly be settled with adequate research work, but it takes a high order of ability and time and money to accomplish anything in this direction, and when the work is completed by the department private resources to carry the scheme further on industrial lines will be necessary. In order that India should become independent of Java sugar the sooner the Agricultural Department turns its attention to the expansion and improvement of cane cultivation in areas within the sugar belt, the greater the possibilities for India to arrive at the necessary state of independence from foreign imports."

On this the *International Sugar Journal*, June 1916, writes as under:—

"*Indian Sugarcane Cultivation.* A Calcutta contemporary, *Commerce*, takes occasion to criticize the Department of Agriculture of India for its policy in devoting its energy to experimental cane work in those provinces of India which it declares are outside the

sugar belt and therefore are quite unsuitable for sugarcane cultivation. These provinces are Bihar, the United Provinces, and the Punjab, and it seems to be concluded in competent circles in India that in them cane cannot be grown satisfactorily owing to adverse climatic and soil conditions. It is therefore asked why the Agricultural Department should employ time and labour on research work for securing cold-resisting canes with early maturing tendencies, when there is ample scope for expansion and improvement in provinces within the sugar belt, such as in Bombay, the Central Provinces, Bengal, Assam, and South India? Our contemporary in fact states that they in India are still waiting for the Agricultural Department to show them if any possible advantage can be derived from such a hopeless policy; and it strengthens its criticism by pointing out that, although plants can to a certain extent adapt themselves and be domesticated outside their climatic belt, the fact remains that their cultivation there never really becomes a commercial success, but will always remain an uncertain proposition. It is possible that the authorities will reply that they have introduced the experiments where they have found that the native population was accustomed to cane cultivation and will take more or less kindly to schemes of amelioration. But it is a fundamental necessity that the soil and climate should be suited to the plant, and if, as *Commerce* claims, the soil and climate of the cited provinces are not suitable, then it does indeed seem a pity to waste time and money on experiments which will certainly not produce any commercial success or assist materially in making India more independent of the supplies of Java sugar. Better concentrate attention and energy on lands within the recognized sugar belt. But we should like to have the official explanation of the policy thus criticized."

On reading these, the first idea that strikes us is that the writer of the article in *Commerce* has completely lost sight of the main point in connection with the Indian sugar industry that the problem in India is a dual one. The word sugar does not solely refer to the refined article which is an obsession firmly fixed in the minds of so many. There are two methods of utilizing the sugarcane when

crushed, namely, *A* the production of *gur* for eating and *B* the production of refined sugar either (i) direct from the cane, or (ii) from *gur*. India's production of sugar (mostly raw sugar) excluding that in Native States is close on 3 million tons of which about 16,000 tons only are exported, the rest is all consumed in the country. Over and above this she has to import over 800,000 tons of refined sugar mostly from Java and Mauritius to meet the continually expanding demand for this kind of sugar. She is therefore far and away the greatest producer and consumer of sugar (raw) in the world, and I would ask what country can possibly supply her with such an enormous quantity. Now the points to be borne in mind are (1) that the vast majority of the Indian population prefer *gur* which is as nutritious as sugar, or rather more so, and (2) that *gur* also enters into many Indian food preparations and there is no likelihood of the demand for *gur* falling off in the near future. On the contrary, the increase in wages and the rise in the price of agricultural produce have enabled certain classes of the labouring and agricultural population to increase their consumption of this commodity. Again, as none of the other sugar-producing countries produce *gur* it must be manufactured within the country itself, for it would not pay to produce it abroad. These being the peculiar conditions we can now proceed to examine how far the tropical parts of India, which are more suited to cane growing, can meet this huge demand. If we refer to the total area under cane in India, we find that about 90 per cent. of the acreage is in Northern and North-Eastern India, *i.e.*, United Provinces, Punjab, Bihar, Bengal, and Assam. Not more than 10 per cent. is in Peninsular India or what may be called the *sugar belt*. It will thus at once be seen that Bombay, Madras, and the Central Provinces cannot possibly supply the total quantity of *gur* required by India. Doubtless it may be asked why not, if there is a market and the land is suitable for cane ? But there are these restrictions. Extension of cane cultivation in these parts is limited by the supply of water, the competition of paddy and such other food crops, and, what is so frequently lost sight of in improving and increasing areas under a particular crop, the economic balance which must be kept level; for unless the price of food is to rise in the district,

the ratio between food and money crops must be kept in that state of balance, which will keep food at its lowest and yet allow the district to grow the greatest amount of money crops available, and it will generally be found that the district has calculated this to a nicety. Canal irrigation is very limited in Peninsular India and irrigation from wells has to be resorted to. This is an uncertain and costly method, and so there is no great extension of area to be looked for in these parts save where new canals are opened. This fact has led districts out of the sugar belt to grow their own cane, for the limiting of the area in the sugar belt would have the effect of forcing up the price of sugar if the demand was great from all other parts of India.

Another reason for their cultivation out of the belt is that cane as a commercial crop is more paying than rice, wheat, or cotton, always provided the necessary labour and water are available and that the cultivator and his family do most of the labour. The following average values of crops in India will make this point clear.

Jute	Rs. 145 per acre.
Sugarcane	Rs. 127 per acre.
Rice	Rs. 52 per acre.
Wheat	Rs. 36 per acre.
Cotton	Rs. 32 per acre.

It will be argued that sugarcane occupies the land for over a year while the other crops occupy at most six months. To this the reply is that in India cultivation of any crop is taken up after the ryot has considered how much labour and cattle power he has at hand and which he must keep employed throughout the year. The ryot looks to his own immediate necessities first. He therefore plants a variety of crops to safeguard himself against ruin resulting from the failure of rains and sugarcane naturally comes high on the list which is the result of a long chain of circumstances proved and tested by years of experience. India is not a country of capitalist farmers with large landed estates. She is a poor country of which the backbone is the illiterate peasantry. The holdings are uneconomic, being small and scattered. Leaving aside the question of expropriation which is unthinkable we have to make the most of the existing situation.

In Bengal, as shown above, jute is more paying. The date-sugar industry in this province is capable of improvement. Some increase in the area under sugarcane is also possible, but the following proverb current in Eastern Bengal will indicate the ryot's ideas about this crop. " Unless a man has seven sons and twelve grandsons he should not cultivate sugarcane." We do not therefore think there is any prospect of a large extension of area under sugarcane in Bengal. It is true that in Assam there are possibilities for developmen, tespecially in Goalpara and Kamrup and Nowgong, but labour in Assam is notoriously deficient and the climate of the country in the rains is not calculated to stimulate the inhabitants to any prolonged physical exertion. Further the waste land suitable for cane cultivation has to be reclaimed, new roads made, and in some places either labour has to be imported or labour-saving machinery, such as steam ploughing tackle, has to be introduced. All this spells capital and it is only large capitalistic concerns that can do all this. Nothing in the way of extension can be hoped for from the comparatively limited areas under cane under the ordinary ryot's conditions and to hypothecate on such a capitalistic basis when dealing with the ryot is to bring your scheme under ridicule. A man who farms on the turn of a rupee can't discern the ultimate money saved by using steam tackle.

Turning to Bihar we can confidently say that if there is any part in India where the development of white sugar manufacture is most promising it is here. Even before the outbreak of war the central factories working in Bihar were a financial success. In some parts of Bihar cane is grown without irrigation. It is true that the out-turn per acre of cane is not high but as the cultivation charges are in the same ratio the crop is a paying one. The *gur* produced in Bihar is of inferior quality suitable only for refining purposes and hence the cultivators are not averse to selling their cane direct to factories. In the opinion of many competent authorities practically the whole of North Bihar is suitable for the growth of cane.

The heavy crops of cane on the Pusa farm where the soil is by no means of the most favourable type in Bihar for the growth of

cane but rather the reverse show what can be done by improved cultural methods. The late Agricultural Adviser to the Government of India was of opinion that by the introduction of an improved cane and improved methods of cultivation in Bihar the production of sugar per acre could be raised to a very much higher figure than it is now, and it is not too much to say that it could be easily doubled. And yet the writer of the article in *Commerce* says the soil is unsuitable in Bihar. We wonder where it is possible to find better, more fertile, and more easily cultivated soil than in Indo-Gangetic alluvium. Its fertility is probably largely due to its water-holding capacity. A crop can exist in it through the hot weather when it would fail in most soils. It is true that the advent of severe cold in November affects the growth of cane and also that the crop is not so heavy as in Java, but this is not so great an evil as to put sugarcane clean out of court. We admit that in Northern India thin reed-like canes are grown. Though the sucrose-content is not very low they have a high proportion of fibre and consequently yield less juice to the mill in single crushing. In other sugar-producing countries thick canes are the rule, giving from 30—40 tons per acre under liberal manurial and cultural treatment. Here the crop does not receive that same amount of attention, and as regards manuring it may almost be said that this nitrogen-loving crop practically goes without it in Northern India. It should, however, be remembered that in Northern India excluding Punjab the average out-turn per acre is never below 15 tons of cane, and the cost of cultivation, etc., does not exceed Rs. 70 as the ryot supplies his own labour and cattle power. The crop is therefore a paying one for him. In favoured localities in Northern India people grow *pounda* canes and they are more profitable, but as a rule they require greater care in cultivation, liberal manuring, and are more liable to disease and also to attacks from jackals, etc., and hence the cultivator who has probably experienced all these set-backs plants thin canes and plays for safety.

Coming specially to the United Provinces which have about 1,300,000 acres under cane it is necessary to emphasize what Mr. Moreland has already pointed out that this crop ensures regular

employment to a large number of labourers at a time when other work is hard to find, and given a good season it enables the cultivator to pay his rent and put something by, or give his family and friends a treat. Further it is the stand-by of the hard-working man, calling for just as much labour as he can put into it, and there is perhaps no other crop which rewards skill and labour to the same degree. Any decline in the cultivation of this crop which usually occupies the superior land should therefore result in the lowering of the standard of agriculture in these provinces; on the contrary, a reasonable extension is eminently desirable in the general interest of the community. After a succession of good years the cane area increases by as much as a quarter of a million acres, and after bad seasons it falls back as much as half a million acres. The area under cane appears to be governed by probable prices and by the economic position of the cultivating classes for the time being, *i.e.*, possession or lack of necessary capital. In short, it acts as a financial barometer of considerable accuracy and delicacy.

It will thus be seen that this crop is of vital importance to the United Provinces. Bengal has its jute as a paying crop, Bihar its indigo or tobacco, but the United Provinces have nothing between cane and far less remunerative crops. It is therefore not a question of a few central factories or a small class of consumers, but affects the welfare of a very large part of the rural population. And as at the outside only $\frac{1}{5}$th of the total production of the United Provinces is converted into sugar it cannot be said that the cultivators are losing over this crop. In fact those parts of the United Provinces like the Meerut Division which export *gur* show an increase in cane cultivation. It is only parts like Rohilkhand which used to export a large quantity of country refined sugar that have felt the competition of the foreign product and shown a decrease in the area under cane. It may be argued that this extensive cultivation of cane in the United Provinces is due to irrigation facilities. We admit that facilities for cheap irrigation have been greater in the United Provinces than in other parts, but so long as no equally paying crop can be substituted the ryots are wise in cultivating cane and the Agricultural Department equally so in trying to

ascertain whether it can help the ryots in increasing their yield of stripped cane per acre or in improving their methods of *gur* manufacture. In fact, while the cultivators hardly get more than 15 tons of cane per acre, on Experiment Stations 22 to 25 tons of sugarcane of a purity of 85 have been obtained. This variation in out-turns indicates vast possibilities of improvement. Already Mr. Clarke has got a type of cane J. 33 which is far better than any *desi* variety at present grown by the ryots. Not only is there no question of the crop being given up in the United Provinces, but there is a possibility of extended area coming under cane as the result of gradual extinction of poppy cultivation.

The Punjab has nearly 15 per cent. of the total area under cane in India. With the increasing popularity of wheat and cotton in this province, there is no substantial increase in the area under cane, taking the province as a whole. While there is a slight tendency to decrease of area in the older districts some expansion has taken place in the new canal colonies, and if it were not for the scarcity of labour and of manure the increase would probably have been greater. It is true that the climate of Punjab is a very severe one in winter and tests the hardihood and vitality of plants to the utmost, and it is especially trying to sugarcane; still in districts with a fairly plentiful and secure supply of water in some form or other its cultivation is relatively important. The question may naturally be asked why this should be so? We have already explained the general conditions which induce the ryots to take up the cultivation of this crop. The province is not able to meet its own demand of *gur* fully, and as it is far removed from the sea-coast foreign sugar has to stand heavy freight charges which acts as some sort of protection. Though the out-turns are low the cultivators will not give up the crop so long as it is paying to them. The ryot is not a capitalist or a specialist with a large capital on hand anxious to increase his profits every year. He is satisfied if a crop provides labour for himself or his family all the year round and leaves some net profit.

We think we have written enough to show that in the rural economy of Northern India this crop plays a very important part,

and hence the Agricultural Department is bound to study the crop with a view to suggesting improvements. As Dr. Barber, the Government Sugarcane Expert, has pointed out we want better, richer canes with larger out-turn in the field, greater resistance to disease, and yet adaptable to the methods of cultivation adopted by the cultivator. Improvement in the last particular will only be likely to come if the variety of cane provided is more responsive to intensive cultivation. Although one or other of the thick tropical canes have been a success on almost every Government farm where they have been tried there is no doubt that as a whole tropical canes are not suited either to the northern tract or the ryot's method of cultivation in vogue there. The tropical thick canes needing good cultivation and heavy manuring are often useless to him for simple lack of the means to grow them properly. What is needed is a hardier type of cane capable of holding its own with the canes grown under field conditions in Northern India. Such types are not usually available among the canes grown in tropical countries, and the only way to get them is to produce them ourselves. No particular variety will suit all parts of the vast area of the Indo-Gangetic plain. A series of seedlings must therefore be evolved, each one specially fitted for the particular region where it is intended to replace the local kind. There seems only one way in which this can be attempted. In each case the best local kind accustomed for centuries to its peculiarities of climate and treatment should be selected out and crossed with the richer southern varieties so as to combine its resistant properties with the imported richness and bulk. The work is thus complicated in that a series of separate problems have to be solved and a separate series of seedlings evolved for each geographical region.

To conclude: It is clear from the above that so long as India requires *gur* in large quantities and refined sugar only in comparatively smaller ones we are not justified in saying that the crop has no right to exist in non-tropical parts. It is only these parts that are able to supply the enormous demand for this commodity, and as cane cultivation is profitable to the ryots in these districts as it stands, it is the legitimate function of the Departments of

Agriculture to institute experiments with a view to find out whether any better varieties can be substituted, or whether any improvements in the cultivator's methods of cultivation and *gur* manufacture are possible, and this opens a wide field for study. While the question of *gur* is receiving attention the problem of white sugar manufacture is not being lost sight of. In the Gorakhpur Division of the United Provinces and in Bihar where sugarcane cultivation is concentrated new central factories are springing up. We do not think it necessary to go over the beaten ground and say what experiments have already been made and what improvements effected in this industry in India. It will suffice if we refer the readers to the article on "Indian Sugar Industry", published in the *Agricultural Journal of India*, January 1916, which gives a useful summary of the present position.

To sum up the case in a nut-shell it is this. Cane is grown outside the sugar belt for very good reasons—reasons which have stood the test of years and so are entitled to every respect, and while a crop continues to pay (for there are precious few unpaying items on the ryots' programme) occupies a considerable acreage and supplies a demand, it is not possible to pass it by. It forms a radical part of the district economy, and unless you have another crop equally useful and paying to replace it by, it behoves you to do your best to improve the existing state of things. To fold your hands and say *kuchh parwah nahin* the crop is outside its proper "area," and to split hairs of that kind is to prove the Department completely out of sympathy with the ryots' present wants. No; until it is possible, and I do not think it will ever be so, to replace the cane crop by an effective substitute and to supply the demand for *gur* from other parts—two jobs which will not be done in this century, if ever, it is up to the Agricultural Departments to endeavour to improve the present cane crop. A definite result accomplished now will repay itself a thousand times over in the confidence which it inspires in the ryots for the future. The proverb of "the horse that starved while the grass was growing" is all too true. The ryot wants help now and help that will improve his present state, and a long list of theories may do on paper but are pretty useless for immediate practice. We shall welcome *Commerce's* reply and our columns are open to it.

THE CLASSIFICATION OF INDIGENOUS INDIAN CANES.

BY

C. A. BARBER, Sc.D. (Cantab.),

Government Sugarcane Expert, Madras.

During the past two years it has been found impossible to proceed with the classification of Indian canes, commenced in the Memoir[1] describing the varieties collected at the Gurdaspur Farm in the Punjab. This has been due to the urgent need for systematizing the seedling work and placing it on a definite basis. The collection of varieties has, however, proceeded during visits to various parts of India and, although the collection is far from complete, a fairly representative series has been got together. The numbers of plots in the cane-breeding station devoted to varieties at present consist of thick (*Pounda* and introduced) canes 120, thin (Indian) canes 112. At each planting season it has been attempted to place the latter plots together in groups of obvious systematic connection. This has been fairly easy with the main classes, *Mungo, Pansahi, Nargori,* and, to some extent, with *Saretha,* but, besides these, there has accumulated a large number of unclassified forms. Among the latter, it is natural that special attention has been attracted to the two large indigenous cane varieties of South India, *Cheni* and *Naanal,* for from them a number of seedlings have been obtained. During the present cropping season (1916) an attempt has been made to deal with the unclassified series and, although the work was necessarily incomplete and rather hurried, results of considerable interest have already been obtained. It has been demonstrated,

[1] **Barber, C.A.** Studies in Indian Sugarcanes, No. 1, *Memoirs, Department of Agricu in India, Botanical Series,* vol. VII, no. 1.

namely, that these two South Indian canes have allies in almost every province, even extending to the Punjab, where their analogues may be found in the *Katha* and *Dhaulu* of Gurdaspur respectively recently described in detail.

Naming these two series after the generally best known members, those that have been most widely distributed for trial over the agricultural stations of India, we may speak of *Saretha* and *Sunnabile* groups. Quite a number of the unclassified list have been ranged under these two heads, and full descriptions, drawings, and photographs have been taken of some of them during the recent harvest.

Among those thus dealt with in the *Saretha* group are *Baraukha Ukh* (Cawnpore), *Ganda Cheni* (Mysore), *Chin* or *Chunnee* (Aligarh, Shahjahanpur), *Hullu Kabbu* (Bellary district of Madras), *Jaganathia* (Bihar), *Khari* (Bengal), and *Saretha* (Meerut).

The *Sunnabile* group includes *Bansa* (S. Bihar), *Bansi*, probably the same as *Khadya* (Bombay), *Dhor* (Harrai and Seoni, Central Provinces), *Kaghze* (Aligarh, Pilibhit), *Ketari* (Behta, Bihar ?), *Mojorah* (Assam), *Naanal* (Trichinopoly and Tanjore), *Putli Khajee* (Assam ?), *Rakhra* (Shahjahanpur), and *Synnabile*, probably the same as *Bansi* (Bombay).

The object of the present note is, firstly, to present a classified list of Indian canes collected in the cane-breeding station, for the use of Provincial Officers, and, secondly, to invite the addition of further varieties which we have not at present obtained. As it is proposed shortly to describe the varieties named above in a Memoir, Provincial Officers are earnestly requested to collect any information that they can regarding the synonyms, distribution, and field characters of these canes, and all such information will be duly acknowledged when describing the varieties.

The following is the preliminary classification of the varieties on the cane-breeding station, with the sources from which they have been obtained :—

(1) *Mungo* group.

Mungo, Sabour.

Paunri, Sabour.

Hemja, Bhikanpore, Sabour.
Buxaria, Sabour.
Burli, Ottur.
Kuswar, Ottur, Partabgarh, Aligarh.
Lewari, Sabour.
Poraya, Sabour.
Matna, Aligarh, Shahjahanpur.
Matna Ukh, Cawnpore.
Rheora, Sabour.
Reori, Partabgarh.
Khatuia, Aligarh.
Agoule 1, Shahjahanpur.
Katara, Barah, Partabgarh.
Ramgol, Partabgarh.
Sarauti, Partabgarh.
Pararia, Aligarh, Shahjahanpur.
Matanvar, Partabgarh.
White Pararia, Shahjahanpur.
Dark Pindaria, Shahjahanpur.
Kharwi, Shahjahanpur.
Patarki Mungo (Partabgarh), Gurdaspur
Matki Mungo, Ottur.

(2) *Saretha* group.

Katha, Gurdaspur.
Lalri, Panipet.
Kansar, Gurdaspur.
Chin, Partabgarh, Aligarh.
Chunnee, Shahjahanpur.
Mesangen, Jullundur.
Saretha, Partabgarh, Jubbulpore.
Dhaur Saretha, Aligarh.
Chynia, Barah.
Baraukha Ukh, Cawnpore.
Jaganathia, Barah.
Ganda Cheni, Mysore.
Khari, Sabour, Jubbulpore.

Hullu Kabbu, Hagari (Bellary District)..
Raksi, Shahjahanpur.
Burra Chunnee, Shahjahanpur.
Ramui, Shahjahanpur.

(3) *Sunnabile* group.
Dhaulu of Gurdaspur, Gurdaspur.
Teru, Gurdaspur, Harchowal.
Ekar, Jullundur.
Dhor, Jubbulpore.
Hotte Cheni, Mysore.
Rakhra, Partabgarh, Shahjahanpur.
Kaghze, Aligarh.
Sunnabile (Bombay), Jubbulpore.
Khadya, Manjri.
Bansi (Bombay), Nagpur.
Putli Khajee (Assam ?), Ottur.
Bansa, Sabour.
Ketari, Sabour.
Mojorah, Assam.
Naanal, Tanjore.

(4) *Pansahi* group.
Ketari, Sabour.
Merthi, Aligarh.
Dikchan, Partabgarh.
Sanachi (Dumraon), Gurdaspur.
Yuba (Natal), Pusa.
Chynia, Sabour.
Kahu, Gurdaspur.
Lata, Sabour.
Maneria, Sabour.
Pansahi, Sabour.
Sada Khajee (Assam ?), Ottur.
Bharanga, Shahjahanpur.

(5) *Nargori* group.
Nargori, Sabour.
Kewali, Sabour.

Baraukha, Sabour, Pursa, Shahjahanpur.
Ketari, Sabour.
Chynia, Sabour.
Sararoo, Jubbulpore.
Manga, Shahjahanpur.
Agoule 2, Shahjahanpur.
Kalari, Nagpur.
Katai, Sindewahi.
Mungo (*sic*), Shahjahanpur.
Newra, Shahjahanpur.

(6) Unclassified at present.
Bodi, Gurdaspur.
Dhaur, Aligarh, Shahjahanpur.
Dhaura of Azimgarh, Gurdaspur.
Dhaulu of Phillaur, Phillaur.
Kinar, Aligarh.
Kanara, Jullundur.
Agol (Pilibhit), Partabgarh.
Khagri, Sabour, Dacca, Rajshahi.
Ikri, Pursa.
Khelia, Sabour.
Barhai (Jubbulpore), Gurdaspur.
Barahi, Jubbulpore.
Barokha, Shahjahanpur.
Shakarchynia, Sabour.
Betakali (Dumraon), Gurdaspur.
Kalkya, Manjri.

Many of these varieties have at present been insufficiently studied, being only recently received. There are certain obvious resemblances among the unclassified canes, which may be of use in the framing of new classes or obtaining connecting links between those already instituted. Thus there is little doubt that *Ikri*, *Khelia*, and *Khagri* are closely connected, while *Bodi*, *Betakali*, and *Dhaulu* of *Phillaur* seem to be transitional stages between the *Sunnabile* and *Mungo* groups. The position of others is not yet very clearly defined. Thus *Putarki Mungo* resembles *Bodi* and

Matki Mungo reminds of *Katha*, although both have been included in the *Mungo* group, and so on. But, in the main, the classes show true systematic connection and, in many cases, different names probably refer to the same cane growing in different parts of the country. The localities mentioned do not always indicate the true places where the canes are grown, as most of the varieties have been received from Government farms where collections have been established for the comparison of different forms. Any information which will help to fix the true vernacular names and the exact range of any variety as cultivated will be of special value.

It is to be noted that the lists given above do not include many well known Indian names. Besides obviously *Pounda* canes, such as *Pundia*, *Shamshara*, *Saharanpuri*, *Poovan*, etc., there are such others as *Kajla*, *Vendamukhi*, *Magh*, *Dahlsunder*, *Yerra*, about which some doubt may exist, and the line is sometimes very hard to draw. But the principle has been adopted of excluding all canes about which there is any doubt, and it is quite possible that further study may cause the introduction of some of the thicker canes into the indigenous series, as has recently been the case with *Mojorah*, *Sada Khajee*, and others. In other words, thickness is not the only determining character, and the present classification can in no sense be considered the last word in the matter.

CATTLE POISONING BY *JUAR* (*ANDROPOGON SORGHUM*) AND ITS PREVENTION.*

BY

C. SOMERS TAYLOR, B.A.,

Agricultural Chemist to the Government of Bihar and Orissa,

AND

M. N. GHOSH, M.A.,

Assistant Professor of Chemistry and Physics, Sabour Agricultural College.

JUAR is a crop which is principally cultivated for fodder in Northern India, and as such the stalks are cut while green, before the ears have formed. It is usually sown in the hot weather before the rains, and in consequence if the rains do not set in early enough the conditions become unfavourable for a good growth and the plants become stunted. Very young plants as well as those which have become stunted, are dangerous to be used as a cattle food, on account of their containing a glucoside which, under certain circumstances, breaks up and yields prussic acid which is a violent poison. The poisonous properties of such *juar* have long been recognized and Watt[1] refers to a prevalent but wrong belief among the Indian cultivators that the poison is the result of an insect which infests the plants when the crop suffers from deficiency of rain. The Indian cultivator, however, could not be blamed for his wrong belief, for even among men of science the true explanation of occasional cattle poisoning by *juar* was not known before 1902, in which year the prussic acid yielding glucoside was discovered.

* Reprinted from the *Agricultural Journal of the Dept. of Agri., Bihar and Orissa*, vol. III, part II.

[1] *Dictionary of Economic Products*, vol. VI.

Owing to unfavourable conditions at the time of planting this year, much *juar* was stunted and many bad cases of cattle poisoning occurred in the villages round Sabour. The first part of June was specially unfavourable for the agriculturists, for the expected showers did not come off and there was a long period of hot and dry weather. The *juar* crops, specially those in high lands, suffered in consequence and there was an accumulation of the poison yielding glucoside in the plants in quantities sufficient to cause fatal effects. As many as nine bullocks died in one village alone, some having strayed into *juar* fields and some having been actually fed with the stunted crop. These deaths were not reported immediately or we should have endeavoured at once to find the quantity of the poison present in the poisoning crop at the time of the death of the animal. In fact ten days passed before we received the information, so that any attempt to estimate the quantity of prussic acid at the time of poisoning was impossible. The weight and constitution of the crop changed very rapidly indeed at that time, and we were therefore compelled merely to estimate the quantities of the poisonous principles in the plants as they stood ten days after they had been found poisonous to cattle. It is likely, however, that at the time of death the quantities existing in the crop were far greater than the amount estimated by us.

The largest quantity of prussic acid that we were able to obtain from the crop of one of the fields where as many as three deaths had taken place was about half a grain per pound of the crop. This quantity may at first sight appear to be small, but when it is considered that only four to five grains of the anhydrous acid in a single dose may be sufficient to cause the death of an ordinary country beast, it is obviously dangerously high. A country bullock will easily eat 30 seers or 60 lb. of *juar* which at the time of our analyses would have contained 30 grains of prussic acid or at least six times the fatal dose. In another field from which no cattle had been fed there was about as much prussic acid as one grain per pound of the crop. Towards the end of June and the beginning of July, there was plenty of rain, the *juar* plants rapidly grew up, and in a few weeks the quantity of prussic acid they were able to furnish, diminished so

much as to be quite harmless. It may strike one as peculiar, that although a large number of goats strayed into the fields and fed upon the *juar* leaves at the same time as the bullocks were dying of poison, yet there was not a single case of mortality among them.

That *juar* is poisonous to cattle in the early stages of its growth and loses its poisonous qualities when it is nearing maturity has long been recognized. We have already said that its poisonous action is due to the presence in the plants of a cyanogenetic glucoside, *i.e.*, a glucoside capable of yielding prussic acid. Glucosides are compounds which on treatment with dilute acids or by the action of unorganised ferments break up into several substances of which glucose (a compound belonging to the sugar group) must be one. Now *Dhurrin*, which is the name given to the glucoside of *juar*, in the same way breaks up into glucose and two other substances of which prussic acid is one. An enzyme or unorganised ferment exists in the plant itself and in presence of water breaks the glucoside up with the result that prussic acid is given out. Dr. Auld [1] maintains that the glucoside itself is not poisonous and that in the animal the saliva and secretions of the stomach have a remarkable effect upon restraining the fermentation of the glucoside, so that an animal may not die, even if it has taken up enough of the pure glucoside. In the case of green *juar*, however, its juices are acid and act in the opposite direction to the saliva and stomach secretions, neutralizing their effects. In consequence it is found that, when the *juar* stalks and leaves are eaten green, fermentation of *Dhurrin* takes place in the stomach itself, and if there is enough of it, the animal dies as a result of prussic acid poisoning. It is possible that immature *juar* if fed with ground chalk would be far less dangerous, as this would neutralize the excessive acidity and prevent the formation of prussic acid.

The amount of *Dhurrin* in *juar* is not constant throughout the life of the crop and changes considerably according to the age of the plants. Climate, weather, and perhaps soil conditions are probably important factors which also determine the change.

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[1] *Journal of Agricultural Science*, vol. V, part IV.

Brunnich's[1] experiments in Australia inform us that the glucoside is never wholly absent, but the quantity gradually diminishes from the first stage of growth to maturity. At the earliest stages of its growth the young plant contains a very large quantity of it and as the plant grows up and nears maturity, the cynogen in the glucoside gradually changes into complex nitrogenous compounds or proteins. In the varieties of *juar* that Brunnich experimented with, he found the quantity of prussic acid to be so great that he recommended that *juar* should only be used when the seed ears are well developed, and that it should not be given to animals which have fasted for some time. Willamon and West[2] have found in America that in about two months the available prussic acid under normal conditions is reduced to a harmless quantity. This is confirmed by the common practice in India which is to allow the cattle to feed upon the plants from the time they are two months old until they are nearly mature. In our experiments in a majority of cases we found the amount of prussic acid to be negligibly small in the case of fully grown plants of about eight weeks old. Willamon and West's experiments also tell us, in what part of the plant most of the glucoside is to be expected. In the first three or four weeks of the plant's life, it is concentrated in the stalks; then it rapidly decreases and disappears from there but apparently persists in the leaves in decreasing percentages until maturity. This explains why the goats which strayed into the same fields as the bullocks at the time when the results were fatal to the latter escaped without any harm, because they ate only the leaves which then contained very little of the glucoside while the bullocks ate the whole plants, leaves, stalks and all and consequently suffered.

It is interesting to note that apparently even under similar conditions of climate and rainfall, the same varieties of *juar* of the same age give widely varying quantities of the poison; that while the crop of one field may be dangerous that of a neighbouring field may be quite innocuous. This is seen from the accompanying

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[1] *Journal of Chemical Society*, vol. 83, page 788.

[2] *Journal of Agricultural Research*, 1915, vol. 4, no. 2, page 179.

table which gives the percentages of prussic acid obtained from the crops of three fields of the village of Khankitta near Sabour. It is possible that this is due to difference in the rates of germination, owing to differences in the moisture contents of the soil in which they were planted. This may give rise to a profitable line of investigation. The samples from each of the fields were collected on the same day and the acid estimated :—

Age of the crop when the first sample was taken	Date of collecting the sample	Number of the field	Per cent. of prussic acid	Grains of prussic acid per lb.
1	2	3	4	5
About six weeks ...	3rd July 1915	1	0·0071	0·497
Ditto ...	Ditto ...	2	0·0045	0·315
Ditto ...	Ditto ...	3	0·0025	0·175
Ditto ...	5th July 1915 ...	1	0·0066	0·462
Ditto ...	Ditto ...	2	0·0025	0·175
Ditto ...	Ditto	3	0·0017	0·119
Ditto ...	7th July 1915 ...	2	0·0007	0·049
Ditto ...	Ditto ...	3	0·0005	0·035
Ditto ...	8th July 1915 ...	1	0·0052	0·364

It will be seen that at the age of about six weeks the crops of different fields, apparently similar, could yield materially different amounts of the poison, and though all of them at the time were more or less dangerous, in less than a week, No. 2 and No. 3 had their quantity of poison reduced so much as to be capable of being eaten with impunity. It has not been exactly ascertained under what conditions of cultivation and growth and at what periods, accumulation of the poisonous element in the *juar* becomes greatest. As our attention was drawn to this late in the season when the plants were rapidly losing their poison, no systematic investigation on the subject could be carried out. The American experiments suggest that manuring of a poor soil sometimes results in increasing the amount of the acid in the plant, but certainly there are other factors more important than the soil, which regulate the amount of the poison.

In this season we altogether analysed 25 samples of which seven were from the Sabour Farm and in all cases the farm crops showed considerably less amounts of prussic acid than the outside

ones. This was expected as the farm crops this year were very healthy and were growing vigorously.

What should the cultivator do, if owing to persistent unfavourable conditions his fodder crop does not grow up properly and shows a dangerous amount of the poison? It is unlikely that sun-drying will be of much use as this process will neither break up the glucoside nor kill the enzyme. In fact it was proved by Brunnich[1] in Australia that sun-drying did not render harmless the poisonous *juar*. As soon as the dry fodder has been soaked in water the enzyme will begin to act upon the glucoside and set the prussic acid free. Instances are not wanting in which the cultivator actually sun-dries a crop which he suspects to be unsafe in the green state, and keeps his dry fodder soaked in water for a considerable time before he feeds his cattle with it. It is just possible that the danger is fairly diminished by this method if sufficient time has been allowed to the enzyme to break up the glucoside entirely, for prussic acid is very volatile and may escape into the air except in so far as it is held in solution by the water present; which at times may be very great. We see therefore that there is a considerable risk in using sun-dried *juar*, firstly, if enough time has not been given to much of the acid to escape, secondly, if there is a good quantity of the acid present in solution after soaking. On the other hand, the process of storing the green fodder in a silo considerably minimizes the danger by breaking up the glucoside, and makes the silage a safe food. This is illustrated by simple experiments conducted in the laboratory at Sabour. The crops of which the prussic acid content had been estimated in the same day were chopped and put under pressure in small drums and were kept in position by lids which were sealed with wax. About three weeks after the lids were opened and the ensilage was analysed and in all cases the quantities of prussic acid obtained were inconsiderably small. That the glucoside was broken up was indicated by distilling the ensilage with water and dilute sulphuric acid, in both of which cases the same amount of prussic acid was

[1] *Loc. cit.*

obtained. The following tables give the results before and after putting in silo :—

No.	Date of analysis and of putting in silo	Before ensilage		REMARKS
		Prussic acid per cent	Prussic acid in grains per lb.	
1	2	3	4	5
1	14th July 1915	0·0043	0·30	Dangerous.
2	20th July 1915	0·0040	0·28	Ditto.
3	19th July 1915	0·0081	0·57	Very dangerous.

No	Date of analysis and of opening the silage	After ensilage		REMARKS
		Prussic acid per cent.	Prussic acid in grains per lb.	
1	2	3	4	5
1	15th August 1915	0·0001	0·0079	Safe.
2	Ditto	Trace	Trace	Do.
3	Ditto	0·0002	0·0138	Do.

From the above we see that a crop contained on the 14th July 1915 as much as 0·3 grain of the poison per pound of the crop. Only 16 lb. of the stuff is quite sufficient to supply five grains of the acid, the fatal dose for a country cow, while only a month after putting the crop into the silo, the quantity of available prussic acid was only 0·008 grain per pound and 500 to 600 lb. of this stuff will be required to produce fatal effects in a cow.

It appears therefore clear that even stunted *juar* will be perfectly safe when fed to cattle after storing in a silo for a few weeks. It is hoped that we shall take up further experiments on this next year.

HOW TO BOTTLE FRUITS, VEGETABLES, POULTRY, MILK, MEAT, ETC., FOR DOMESTIC AND COMMERCIAL PURPOSES.*

BY

E L. ROUT,

Inspector of Agriculture, Cuttack.

THE above is the title of a book by ex-Sergeant-Major George Fowler in which are explained in a simple and lucid manner instructions to preserve fruits, vegetables, and other foods in bottles and jars.

Sergeant-Major Fowler has patented special apparatus and bottles for this purpose. When sterilized in this apparatus the above-mentioned articles can be preserved in the vacuum bottles and jars for an indefinite period.

With the kind permission of Mr. James Taylor, Deputy Commissioner of Angul, who has the apparatus and has started preserving with success garden produce of winter vegetables such as peas and beans and has also preserved snipe, the writer is able to furnish this article, with the hope that others who are interested in this work might take it up.

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APPARATUS.

The outfit consists of a bottling apparatus of tin with a thermometer, vacuum bottles, clips and rubber washers or rings, a brush for cleaning the bottles. The thermometer is placed on the side of the apparatus made for holding it in, which is connected with the inside by a passage through which the water

* Reprinted from the *Agricultural Journal of the Dept. of Agri., Bihar and Orissa*, vol. III, part II.

comes in and marks the temperature. The apparatus for heating can be used on an ordinary kitchen or oil stove or a gas burner. The following is a brief description. Full details cannot be given as the system is patented, but instructions accompany the apparatus.

How to sterilize. Put the bottle filled in with fruits or vegetables (cooked or uncooked as the case may be and covered with patent covers with rubber rings) into the apparatus containing water half to three-quarters the height of the bottles. Heat the water slowly to a certain temperature. Now reduce the heating medium and then let the bottles remain in the apparatus at a lower temperature.

If the bottled fruits be intended for commercial purposes the contents of the bottles must not be sterilized at too high a temperature in order to avoid breaking, shrinking and rising of the contents in the bottles which will mar the value of the articles.

Take out the bottles, taking care to keep them on wood or thick paper as the jars might crack in contact with a cold surface such as marble or iron. Keep for 48 hours with the clip or clips on, when they may be taken off or used for other bottles. If the bottles are hermetically sealed the covers should be fast on them, if not then the cause should be rectified and the sterilization repeated.

An unsuccessful sterilization would cause air to get in and ferment the stuff in 18 to 36 hours or become mouldy in a few weeks. If all the germs contained, in the fruit, vegetable or meat, etc., have not been destroyed by sterilization although the bottles are found to be sealed hermetically fermentation will occur and gases collect within the bottles.

The secret of bottling is the thorough sterilization of the articles, on which depends the destruction by heat of every germ in the water and contents within the bottles and the exclusion of air during the process when hermetical closure of the lid is caused by the air being exhausted from the bottles during the heating. To ensure a more perfect vacuum the cover should be on the apparatus.

As both cooked and uncooked articles are preserved the process for each of the methods is slightly different.

For bottling cooked vegetables a high temperature is absolutely necessary. The vegetables must be freshly gathered, prepared, washed in salt and water and cooked (for peas and beans boiling is done for two or three minutes only). Then they are dipped in cold water for a few seconds before being put into the bottles. The bottles must be washed beforehand and put into three-quarter ounce of salt. Fill them with cold water and close them with cover and clip (not using the rubber washers or rings). Add salt to the water in the sterilizing apparatus from 1 lb., 2 lb., 3 lb. according to the size of sterilizing apparatus. After sterilizing for the first time for two hours at a high temperature it should be continued again at an interval of 48 hours at a lower one. The clips should not be removed after 48 hours have elapsed after the second sterilization. Thus the vegetables are bottled and kept for use.

The cost of the apparatus varies from 20*s*. to 50*s*., including a number of bottles, and can be had of Geo. Fowler & Co., 72, Queen's Road, Reading, England.

In India, where there is so often a superfluity of fruit and vegetables at one season of the year and total absence at another, the advantage of bottling surplus produce is evident.

AGRICULTURAL AND VETERINARY OFFICERS ON MILITARY DUTY.

The following Officers of the Agricultural and Veterinary Departments are serving with His Majesty's forces for the period of the war. Any further particulars as to their movements, transfers, etc., will be published here if notified to the editor.

Name	Designation	Particulars regarding service
IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA.		
Major J. W. Leather, V.D., F.I.C.	Lately Imperial Agricultural Chemist, Pusa.	Joined the Army in England. A Major in the 3rd Garrison Battalion of the Cheshire Regiment.
J. H. Walton, B.A., B.Sc. ...	Supernumerary Agricultural Bacteriologist, Pusa.	Joined the Indian Army Reserve of Officers on 4th June, 1915, on active service in Mesopotamia.
S. N. Mitra ...	Assistant, Mycological Section, Pusa.	Joined the Military Service on 6th July, 1916, as Indian Warrant Officer, to help Captain C. F. C. Beeson in dealing with the fly nuisance in Mesopotamia.
P. G. Patel ...	Assistant, Pathological Entomological Section, Pusa.	Ditto.
H. N. Sharma, B.A. ...	Ditto ...	Ditto.
L. S. Joseph, G.B.V.C. ..	Veterinary Assistant, Pusa.	Ditto.
P. C. Kar ...	Fieldman, Mycological Section, Pusa.	Ditto.
T. V. V. Subramania Aiyer.	Typist, Entomological Section, Pusa.	Ditto.
P. Narayanan ..	Artist, Publication Branch, Pusa.	Ditto.
D. P. Singh ...	Fieldman, Pathological Entomological Section, Pusa.	Ditto.
IMPERIAL BACTERIOLOGICAL LABORATORY, MUKTESAR.		
R. V. Norris, M.Sc. (Manch.), F.I.C., D.Sc. (London)	Physiological Chemist, Imperial Bacteriological Laboratory, Muktesar.	Joined the Military Department on the 7th of October, 1916; now on active service in Mesopotamia as Second Lieutenant, I. A. R. O., attached to 112th Mahratta Infantry.
G. H. K. Macalister, M.A., B.C., M.D., D.P.H., M.R.C.S., L.R.C.P.	Pathologist, Imperial Bacteriological Laboratory, Muktesar.	Permitted to apply for active service under the Director-General, Indian Medical Service.

Name	Designation	Particulars regarding service
BENGAL.		
K. McLean, B.Sc. (Edin.) ...	Deputy Director of Agriculture, Dacca.	Has already applied to join the Indian Army Reserve of Officers.
A. D. MacGregor, M.R.C.V.S.	Officiating Superintendent, Indian Civil Veterinary Department.	Posted to Meerut on the 18th February, 1916.
P. J. Kerr, M.R.C.V.S. ...	Superintendent, Indian Civil Veterinary Department.	Serving with Expeditionary Force, D. No. 9, Field Veterinary Section, with effect from 10th July, 1915.
Nalinakshya Basu ...	Veterinary Assistant ...	Serving in 45 Corps, Ambala Cantonment, from 14th May, 1916.
Nagendra Nath Banerjee ...	Ditto ...	Serving in 47 Corps, Lahore Cantonment, from 21st May, 1916.
Bidhu Bhusan Sen ...	Ditto ...	Officer in charge Transport Corps, Lucknow, from 9th May, 1916.
Jitendra Nath Sen Gupta	Ditto ..	Officer in charge Transport Corps, Lucknow, from 15th May, 1916.
Khagendra Nath Ghosh ...	Ditto ...	Serving in 71 Camel Corps, Ferozepore, from 2nd June, 1916.
Sailendra Lal Sen ...	Ditto ...	Serving in 16 Grantee Camel Corps, Rawalpindi, from 14th June, 1916.
Jagman Singh ...	Ditto ...	Serving in 33 Cavalry Depôt, Saugor, from 20th May, 1916.
BIHAR AND ORISSA.		
E. J. Woodhouse, M.A., F.L.S.	Economic Botanist and Principal, Sabour Agricultural College.	Joined the Indian Army Reserve of Officers on 14th March, 1915, serving as Lieutenant, Central India Horse, I. E. F. "A."
N. S. McGowan, Diploma in Agriculture (Cantab.)	Professor of Agriculture, Sabour.	Joined the Indian Army Reserve of Officers on 8th March, 1915, served as Second-Lieutenant, 53rd Sikhs, I. E. F. "E." Wounded in action and is in hospital.
UNITED PROVINCES.		
A. E. Parr, Ph.D., M.A., B.Sc., M.S. ...	Deputy Director of Agriculture, Aligarh.	Attached to 11th Cavalry, with effect from 31st August, 1915.
R. D. Fordham ...	Garden Overseer ...	Attached to Indian Expeditionary Force "B," South Africa.
W. S. Smith ...	Ditto ...	Ditto.
T. S. Davies ...	Deputy Superintendent, Indian Civil Veterinary Department.	Private Anglo-Indian Force attached to 1st South Lancashire Regiment, Quetta.
M. Sadiq Husain ...	Veterinary Assistant ...	27th Mule Corps, Peshawar.
Sirdar Jogendra Singh ...	Ditto ...	3rd Skinner's Horse, Bareilly.
Sirdar Kehar Singh ...	Ditto ...	16th Cavalry, Lucknow.

Name	Designation	Particulars regarding service
	United Provinces—contd.	
Sirdar Murat Singh ...	Veterinary Assistant ...	34th Prince Albert Victor's Own Poona Horse, Ambala.
Sirdar Niranjan Singh ...	Ditto ...	36th Jacob's Horse, Ambala.
M. Bashir Mohamed Khan	Ditto ..	38th King George's Own Central India Horse, Agar.
Sirdar Nand Singh ...	Ditto ..	41st Mule Corps, Sialkot.
M. Abdul Rahman ...	Ditto ...	46th Mule Corps, Rawalpindi.
Rai Kedar Nath ...	Ditto ...	17th Mule Corps, Bannu.
Munshi Rahat Husain ...	Ditto ...	49th Mule Cadre, Lahore.
	PUNJAB.	
H. Southern, M.A. ...	Deputy Director of Agriculture, Gurdaspur.	Joined the Indian Army Reserve of Officers on the 12th of March, 1915, as Second-Lieutenant, Expeditionary Force. Reported missing in Mesopotamia; unofficially understood to be a prisoner in Turkish hands.
	BOMBAY.	
T. Gilbert, B.A. (Cantab.), Diploma in Agriculture (Cantab.)	Deputy Director of Agriculture, Southern Division, Dharwar.	Has already applied to join the Indian Army Reserve of Officers.
E. S. Farbrother, M.R.C.V.S.	Veterinary Officer attached to the Office of the Superintendent, Civil Veterinary Department, Sind, Baluchistan and Rajputana.	Ditto.
	MADRAS.	
E. Ballard, B.A., F.E.S. ...	Government Entomologist	Joined the Army in England with effect from 12th February, 1916; serving in Royal Field Artillery.
W. J. D'Costa ...	Veterinary Inspector ...	Joined the Army on the 5th of November, 1914; Veterinary Inspector attached to No. 10, Field Veterinary Section, Indian Expeditionary Force "D."
S. C. Jeyasingh Raj ...	Veterinary Assistant ..	Served in the Military Department from 25th November, 1914, to 26th January, 1916, when he returned to his original post, being invalided for military duty.
S. R. Lakshman ...	Ditto ...	Serving in the Army Department since 11th May, 1916, as Reserve Veterinary Assistant through the Base Transport Officer, Indian Expeditionary Force "D," Makina Masus.
R. Rajamanikkan Pillai ...	Ditto ...	Serving as Veterinary Assistant, 20th Duncan Horse, Neemuch, from 1st April, 1916.

Name	Designation	Particulars regarding service
CENTRAL PROVINCES.		
J. H. Ritchie, M.A., B.SC. ...	Deputy Director of Agriculture, Western Circle, Nagpur.	Has already applied to join the Army.
L. M. Roy ...	Veterinary Inspector ...	35th Scinde Horse, Jubbulpore.
Abdul Rahman ...	Ditto ...	Depôt 29th Lancers, Saugor.
Hemraj Singh ...	Veterinary Assistant ...	2nd (Rawalpindi) Division.
Atta Mahomed Khan ...	Ditto ...	Ditto.
D. Mulla Singh ...	Ditto .	Ditto.
M. A. Gafoor Khan ...	Ditto ..	Ditto.
B S. Pardeshi ...	Ditto ..	Ditto.
Mohan Lal Bali ...	Ditto ...	45th Mule Corps, Ambala.
P. S. Nair ...	Ditto .	54th Camel Corps, Lahore Cantonment.
R. K. Patankar ...	Ditto ...	71st Camel Corps, Ferozepore.
Mirza Kurshed Ali Beg ...	Ditto ...	Ditto.
Qazi Minhazuddin ...	Ditto ...	Not yet posted.
ASSAM.		
A. G. Birt, B.SC. (Durham)	Deputy Director of Agriculture, Assam.	Joined the Indian Army Reserve of Officers on 30th April, 1915; attached to the North Staffords Regiment and then transferred to the 87th and 82nd Punjabis. Invalided to India temporarily.
U. Kollington ...	Veterinary Assistant ...	Posted to 3rd (Lahore) Divisional Area; Jullunder.
Suresh Chandra Chanda ...	Ditto ..	Attached to 8th (Lucknow) Division, Lucknow.
BURMA.		
Colonel G. H. Evans, C.I.E., A.D.C., M.R.C.V.S.	Superintendent, Civil Veterinary Department.	Served at Rangoon as Port Defence Volunteer from 5th August, 1914, to 15th January, 1915.
Major T. Rennie, M.R.C.V.S.	Second Superintendent, Civil Veterinary Department.	Ditto.

NOTES.

The Preparation of Indigo Paste. MR. W. A. DAVIS, the newly appointed Indigo Research Chemist, instituted experiments immediately on his arrival in India to ascertain the best methods of preparing indigo paste of standardised indigotin content and of preserving such paste from bacterial change during storage or transport. He has established that there is no real difficulty in preparing an indigo paste containing approximately 20 per cent. indigotin.

A large scale sample of about ½ ton of uniform indigo paste was prepared at the end of July at the Honourable Mr. D. J. Reid's factory at Belsund and this has been sent to England for the dyers to report upon.

Experiment has shown that probably the best method of rendering the indigo paste stable is to make it slightly alkaline during mixing, by adding about 0·5 per cent. of soda ash. Such paste can be kept for months without showing any development of bacteria or change in composition. There will be no difficulty in preparing homogeneous indigo paste provided a suitable mixing machine is installed in the various factories. We await with interest further developments.—[EDITOR.]

* * *

The Improvement of Fodder Production in India. The improvement of cattle in India depends largely on a plentiful supply of good fodder. This fact is now being generally recognized and few people are to be found who believe that any real progress can be made in animal production if the food-supply remains, as at present, a limiting factor. The first step in the problem is to feed the animals which already exist. The creation of new types and the improvement of the present breeds by selection are

matters of secondary importance in so far as the cultivator is concerned.

The increased production of fodder per unit area is one of the subjects which has been taken up at the Quetta Fruit Experiment Station. In order to get the land into condition for fruit and also to provide a cover-crop between the rows of young trees, various annual fodder plants have been tried. Of these, Persian Clover or *shaftal* (*Trifolium resupinatum*) has proved the most satisfactory. This is a rapidly growing annual which can make use of the winter rains and which gives a large amount of fodder, the last crop of which forms an excellent green manure. An account of the cultivation of this crop and of the preparation of clover hay has already been published.[1] In the present note, the best method, so far discovered, of inducing the crop to give the highest yield per acre is dealt with.

Where the irrigation water is limited, as at Quetta, two means of increasing the duty of water in fodder-growing have been found successful. In the first place, crops like *shaftal* grow faster and need less water if the land is manured in the first instance with farm-yard manure at the rate of about fifteen to twenty tons per acre. The manure apparently increases the aeration of the soil for the benefit of the root-nodules and the effect on the land is not lost in subsequent years. Indeed the growth of the *shaftal* improves the fertility and the second year's crop without manure is better than the first. The second method of making the water go further is by the proper grading of the surface so that the irrigation water flows evenly over the land. In such fields, long narrow *kiaris*, about $300' \times 25'$, can be watered easily from one end from a well-made, turfed distributary. The expense and trouble in grading and levelling and in the adoption of the most suitable form of *kiari* is well repaid by the amount of water saved, by the ease with which irrigation can be carried out and in the evenness of the resulting crop.

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[1] Clover and Clover hay, *Bulletin no. 5, Fruit Experiment Station, Quetta,* 1915 (reprinted in the *Agricultural Journal of India*, vol. XI, p. 71, 1916).

During the past season, one of the plots at Quetta which was not in very good condition was put down in *shaftal* in August 1915. The land was manured with farm-yard manure at the rate of about 20 tons per acre and sown with *shaftal* under a thin cover-crop of maize. The area of the plot was 0·6735 acre and five cuts were taken as follows :—

	lb.
1. First cut on October 18th, 1915	1,325
2. Second cut on December 2nd, 1915	4,185
3. Third cut on March 14th, 1916	6,040
4. Fourth cut on April 20th, 1916	12,730
5. Fifth cut on May 19th, 1916	13,737
Total of five cuts ...	38,017

The last crop, which was about the same as the fourth or fifth in weight, was not harvested as this particular plot was kept for seed. Taking this at 12,000 lb., the total of the six cuts would have amounted to 50,017 lb. of green fodder. This works out at 33·15 tons per acre per annum. At eight annas per 100 lb., the year's produce would be worth Rs. 371 per acre, an income obtained with the minimum expenditure of water and resulting in an increase in fertility. This result, which has been confirmed many times at Quetta, indicates the methods which should be adopted in fodder growing on alluvial soils in India—intensive cultivation combined with the minimum expenditure of irrigation water. It is probable of course that still heavier manuring would give more cuts and more produce per cut. This has not been tried up to the present as the supply of farm-yard manure in the Quetta valley is limited and there is no point in discovering improved methods which cannot possibly be applied.—[A. HOWARD.]

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A PAPER on "**Scientific Agriculture in India**" by MR. JAMES MACKENNA, M.A., I.C.S., Agricultural Adviser to the Government of India, and Director, Agricultural Research Institute, Pusa, was read at the meeting of the Royal Society of Arts on 27th April, 1916, by Sir Steyning W. Edgerley, K.C.S.I., K.C.V.O., C.I.E. The paper was much on the lines of his recent monograph on "Agriculture in India." The discussion which followed is published in the

Journal of that Society, Vol. LXIV, No. 3316, June 9, 1916, and is reprinted here as it contains much that is suggestive and illustrates the different points of view which appeal to workers in different lines.

The Chairman (Sir Robert W. Carlyle), in opening the discussion, said the out-turn of rice in India far exceeded that of any country in the world of which we had accurate figures, it being grown over an area which was almost equal to that of Great Britain and Ireland. The production per acre, however, was not at all satisfactory. Compared with countries like Italy and Spain it was very poor, the out-turn in Spain being on the average about five times as great per acre as that in India. In the out-turn of wheat India was second to the United States and Russia, it being grown over an area greater in extent than England. The importation of Indian wheat last year played a great part in preventing an exorbitant rise of prices at a critical period. Here again the production per acre was low, it being barely one-third of the average out-turn in this country. India had the second largest out-turn of cotton in the world, taking second place to the United States. As regards sugarcane, it headed the world. The out-turn per acre was bad, the average in India being about one ton of raw sugar per acre against four times that amount in Java and Hawaii. Thus there was a large margin for improvement in quantity and very often in quality of the crops grown over large areas in India. It was impossible to hope that, within any reasonable number of years, the out-turn of rice or wheat per acre would approach that of Spain or England, but it was possible by scientific agriculture to obtain something very much better than the present meagre results. The author had indicated that it was expected in a few years, owing to one improvement in wheat alone, to make £5,000,000 a year more than at present. That improvement affected only one-sixth of the area under wheat, and it would bring the yield up to about one-half of what it was at present in England. The improvement of agriculture in India was, he believed, the greatest problem now before that country. The Indian agriculturist often did admirable work so far as his means allowed, and by many centuries of experience he

had evolved excellent methods, but their practice could be improved by scientific application. He did not in the least underrate the importance to India of general industrial development. It was very desirable that the proportion of the population entirely dependent on the vicissitudes of the seasons should be diminished; but the main staple of India must for all time, so far as he could see, be agriculture. The development of agriculture was not only of vital importance to India from the point of view of the economic welfare of the people, but also of very great importance politically. He believed that under Indian conditions, no political development could be altogether sound which had not at its base a prosperous peasantry capable of understanding and taking its full part in the local administration. It was very fortunate that just at the time when, under Lord Curzon's government, the Agricultural Department was put on its present lines, the great co-operative association movement was also developed. He looked to that movement to produce a profound transformation of Indian social conditions. In the ten years that elapsed since it was first really started, 750,000 members had joined the associations, and he had seen in all parts of India the great increase in the well-being and well-living of villages where they flourished. As the author had pointed out, the two directions in which agriculture would greatly benefit by the movement were, firstly, that it enabled the Agricultural Department to deal with bodies of agriculturists instead of with single cultivators; and, secondly, it enabled the cultivator to borrow money at a rate of interest so low as to enable him to apply capital to the soil with profit. The cultivator had not, so far, availed himself of that privilege to any great extent, but he was sure that there would be rapid development in this direction, and that, owing to the influence of the associations, much more capital would be applied to the soil. India owed a great debt of gratitude to Lord Curzon for his action in regard to agriculture in India. It was very largely owing to the interest that he had taken in the matter, and to his insight into the best methods of furthering it, that the Agricultural Department owed its organization on present lines; and it was also largely due to him that legislation was passed

which made co-operative associations possible, and which provided the administrative machinery for stimulating the growth of such associations. It was also under Lord Curzon's *régime* that Sir Colin Scott-Moncrieff's committee was appointed which investigated the possibility of developing irrigation in India, and the result of its labours had been that the amount of work done since then on irrigation had enormously increased. All the time he was a Member of Council he never experienced any difficulty in getting money for any irrigation scheme which was ready. The author had shown in his paper a thorough grasp of the problems with which the Indian Agricultural Department had to deal, and he was sure the country would derive great benefit from his knowledge and capacity during his tenure of office as Agricultural Adviser.

Sir H. Evan M. James, K.C.I.E., C.S.I., thought from his experience, going back fifty years, that very great difficulty would be experienced in getting the conservative agriculturists of India to support the Agricultural Department. Fifty years ago there was a great demand for good Indian cotton in consequence of the American War, and a very distinguished Collector, without any assistance from Government, bought up all the seed which he could procure of the best variety then on the market, called Hinginghat, and forced the ryots to sow it. If any ryot sowed any of the old bad indigenous cotton his crop was pulled up. As a result, in the first year the ryots of that district benefited to an incredible extent, owing to the superior value of the new crop. At the conclusion of the American War interest in Indian cotton on the Liverpool cotton market died out, and an Act which had been passed in Bombay to prevent the adulteration and mixing of cotton was, at the instance of the Bombay merchants, repealed. As a result Indian cotton again became a byword in the market; but a fresh attempt was now being made to revive the cultivation of better staples. Unless, however, the Government of India were prepared to go further than merely introducing good staples, by insisting on their being grown and kept pure, all the very benevolent experiments referred to in the paper were, so previous experience proved, likely to prove abortive. The ryot was a very nice fellow, but he was very

conservative; and although undoubtedly a good deal might be done in the way of improving Indian cotton, it was a very long and hard climb uphill to do anything really practical and permanent. Nevertheless, he wished every success to the Department.

Sir Andrew H. L. Fraser, K.C.S.I. (formerly Lieutenant-Governor of Bengal), differed entirely from the remarks made by Sir Evan James, his experience making him an optimist in regard to the future of Indian agriculture. He believed the Indian cultivator was perfectly ready to adopt any method which was actually proved to pay, but it was necessary to show him that something was to be gained by adopting the recommendations of the Department. It was not his experience, especially in later years, that it was difficult to get the ryot to move in the right direction. He was very glad to think that the abominable heresy that an improvement in agriculture could only be obtained through the medium of large capitalist cultivators had now been dispelled. Capital was, of course, necessary; but he would rather give up hope of improvement than see the smaller cultivators swallowed up. The growth year by year of the co-operative system, which had been initiated with so much success, filled him with the greatest belief in the future of Indian agriculture.

Lieutenant-Colonel S. H. Godfrey, C.I.E., Indian Political Department, said that Central India contained many forest tribes which took very reluctantly to agriculture, but which worked very keenly on the development of forest produce. The importance of lac was brought home to him shortly before the war. The Maharaja of Rewah started a lac factory on up-to-date lines in order to develop that very important industry in Central India, and shortly before the war Germans offered to take the whole of its output, which they mixed with cheap German alcohol and exported as varnish. When war broke out the German trade stopped, and the forest tribes were threatened with the elimination of their means of livelihood. Two small States in Central India, in order to rescue their forest tribes, started a scheme to work the factory themselves, which proved successful: and as the markets in Central India for forest produce were limited, a project was submitted to the Government of India

to develop a wider ambit for the Native States which had the various forest tribes depending upon them. It was approved by the Government of India, and the Maharajas of Dattia, Panna, and Chhattarpur, the Rajas of Nagod and Maihar, and the Chaube-Jagirdars of the Baghelkhand Political Agency formed a private limited liability company for the development of the work. Shortly after the beginning of the war, Cawnpore was suffering from the want of tannin; the Chiefs employed a scientific expert to report on their produce, and they discovered they possessed some very valuable tannins which were wanted by the Cawnpore factories for the manufacture of army equipment. The company at present deal with lac, tannin, and hides, and the Maharaja Holkar of Indore had established a factory for the manufacture of vegetable dyes for the replacement of aniline dyes. It was the first co-operative State scheme that had been started in India, and had great possibilities. The Central Indian States covered a very large area, from which it might be possible to obtain acetone by dry distillation, and tannin, the latter of which would go far towards supplying a very sore need at present in India, which had to be met by the importation of wattle bark from countries as distant as South Africa. If encouragement were given to the far-sighted and patriotic Indian Chiefs who had risked their money in the concern, it would not only benefit them and their people, but it would go a long way in the scientific development of other States. The Chief Commissioner of the Central Provinces had signified his approval of the scheme by giving to the company large tracts of forest in the northern portions of the Central Provinces on what was practically a profit-sharing basis, which seemed to show that a responsible official had some belief in the development of Central Indian forest produce on scientific lines. His Majesty's Secretary of State for India had sent a tannin expert to India and Burma with instructions to visit the Native State factory at Maihar, in Central India.

Mr. A. Yusuf Ali, I.C.S. (retired), pointed out that the apparent slowness with which agricultural improvements were introduced into India was not due so much to the unreasonable attitude of the ryots or of the people as to certain conditions which made it difficult

for them to utilize those processes from which they were convinced they could make money. He was an optimist in regard to the improvement of Indian agriculture in the future, but there were four main difficulties in the way of a greater scientific application of improved methods. Firstly, the ryots had very little capital. Although agricultural co-operation had placed within their means the power of combining together and raising capital, it must be recognized that the co-operative credit movement was in its infancy, and as long as rates of interest of 9 and 12 per cent. prevailed it was impossible to speak of the salvation of agriculture in the matter of borrowing capital. The second need of the Indian agriculturist was a better organization not only in regard to the selection and issue of good seed, but in the selling of the produce. The ryot often received far less than his due for his produce, a larger proportion than was equitable going to the middleman. Thirdly, a more favourable fiscal arrangement was required. Many of the by-products of agriculture were not utilized because the ryot sometimes felt that he was handicapped by the Revenue Law. A great deal had been done in recent years in the Northern Provinces in the way of ensuring to the ryot the benefit of any improvements he made, but he did not have as much protection as he should do. The zemindars were also chary in many cases of investing capital in the land, because they found that, in the periodical settlement, they did not always obtain the results which were contemplated under the Revenue Law. An improved Revenue Law in regard to the partition of land was required. Small holdings were sub-divided to such an extent that holdings of less than one acre existed. Such minute sub-division was not necessary, and it would be found in many cases that they were merely paper sub-divisions. It was necessary to insist that in Revenue partitions the holdings should be compact and not scattered about. The most important necessity of all was improved agricultural education, because in his opinion more capital would be forthcoming, better organization would be available, and better fiscal arrangement would be insisted upon when the agriculturist was better educated. Education—the right sort of education—was the crux of the matter, and he would

like to have seen more attention devoted to that subject in the paper.

Sir Frederic S. P. Lely, K.C.S.I., C.I.E., expressed his sense of admiration of the silent but substantial work that had been done in India during the last few years by the Agricultural Department. Compared with earlier days there had been an enormous advance in the manner in which the Government had dealt with the subject.

Mr. J. S. Beresford, C.I.E., said the agricultural conditions in Egypt were very much the same as in India, but there was a great difference in the results obtained and the rentals charged for the land. The difficulty in India was that the cultivator had a very small amount of capital, whereas in Egypt the farmer thought nothing of spending £2 an acre on imported artificial manures, without which the large crops grown could not be produced. He doubly recouped the expenditure by the greater yield. It was impossible for the best production from the land to be obtained without the expenditure of capital, and in any new schemes the Government of India introduced that fact must be borne in mind. It was of interest to mention that since the Agricultural Society of Egypt took in hand the purchase and distribution of artificial manure the consumption had largely increased. The import in 1909 was 21,000 tons, value £178,000 ; while in 1912 it had risen to 70,000 tons, value £668,000. Ninety per cent. of this was nitrate of soda. It was chiefly due to the judicious application of such manure that the high level of production in Egypt was now maintained, for the supply of nitrates from the numerous ruins in the country, on which the people formerly relied, was fast becoming exhausted.

Sir Daniel M. Hamilton, in proposing a hearty vote of thanks to Mr. MacKenna for his admirable paper, thought the last speaker had put his finger on the weak spot in Indian agriculture, *viz.*, the want of finance on the part of the cultivator. It was impossible to build up any industry unless it had a sound system of finance at its foundation. Until the financial question was settled he was afraid Indian agriculture would not advance as rapidly as it should do. He recently read a paper by Mr. Howard calling attention to the fact that the surface soil of India, which was the best part of

the soil, was being washed away. Mr. Howard advocated the erection of irrigation bunds to hold up the soil, but such work could not be carried out without money. So far as manures were concerned, he hoped a trial would be made in India of the bacterialized peat discovered by Professor Bottomley of King's College. It had been proved to be a first-class manure, and was, he understood, being manufactured by the Manchester Corporation at £3 a ton. The Government had recently appointed a Commission to study the question of helping Indian industries. Everything possible should, of course, be done to help manufacturers of every kind, but it was often forgotten that the agricultural population of India must always be the great purchasers of manufactured goods, and it therefore seemed to him that one of the ways in which the industrial development of India could best be helped was to develop her agriculture in every possible way.

Sir Frederic W. R. Fryer, K.C.S.I. (late Lieutenant-Governor of Burma), in seconding the motion, fully endorsed Sir Andrew Fraser's statement in regard to the willingness of the ryot to take up any improvement provided he could be convinced that it would pay him to do so. When he was Deputy Commissioner of Hazara he introduced to the sugarcane growers the iron mill made by Mr. Milne, and they adopted it in preference to their wooden mill, as it could be worked with one bullock instead of two; but they would not use the English plough because it necessitated the use of two men and two bullocks, compared with one man and one bullock with the native plough. The cultivators in India were always ready to adopt any improvements that were visible to their personal observation, and he was certain they would be only too pleased to avail themselves of the services of the Agricultural Department. That Department was evidently doing very good work, and the development of agriculture was, as Lord Curzon perceived, one of the first objects to which the Government should devote its attention.

The Chairman, before putting the motion, said that Sir Evan James's scepticism was not altogether unnatural, as cases had occurred in which the cultivators had thrown away the whole advantage they had gained from selection of seed by adulteration on a

large scale. The Agricultural Department was now fully alive to that danger, and the organization was so good that it was not likely to occur again. He also thoroughly agreed with Sir Daniel Hamilton's remark that finance was of the greatest importance to agriculture.

The resolution of thanks was then put and carried unanimously.

Sir Steyning Edgerley promised that the vote of thanks which had been so heartily passed should, in due course, be communicated to Mr. MacKenna. The suggestion was made in the paper that organized development was begun in Bombay by Mr. Mollison, but he was sure that gentleman would be the first to acknowledge the labours of a Bombay civilian, the late Mr. Edward Ozanne. He went home to Cirencester in 1881, took his M.R.A.C., and on his return to India was appointed in 1883 the first Director of Agriculture in Bombay. Mr. Ozanne did much spade work between 1883 and 1890, and had successfully dealt with the dairy industry, the number of dairies run on scientific lines having been raised from one to about 800 by 1888, if his memory was correct. He thought it would be found that it was because of Mr. Ozanne's success that the business in Bombay outgrew his powers of dealing with it, and it became possible to convince the Government of India that there was a good case for bringing out Mr. Mollison as Superintendent of Experimental Farms in 1890. It remained only for him to express the thanks of the Committee to Sir Robert Carlyle for kindly presiding that afternoon.

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WE quote the following from an article on **Ayrshires in India** printed in the *North British Agriculturist* and reproduced in the *Journal of Dairying and Dairy Farming in India,* Vol. III, Part II.

"The native cattle of India are almost entirely of the humped type. They are very useful and docile cattle in the main, but they are not heavy milkers. They, however, yield very well in butter-fat, the average as a rule being about 4½ per cent. The problem set before Mr. Smith (Assistant Director of Dairy Farms), and his fellow-

workers, therefore, was to find the breed most suitable to cross with these cattle in order to increase quantity, and at the same time not materially reduce the butter-fat yield. The importance of maintaining the butter-fat ratio will be apparent when it is stated that the milk supplied regularly to the Army authorities is expected to average about $5\frac{1}{2}$ per cent. of butter-fat. The way that this is done is to keep attached to each farm a certain number of buffalo cows, and to mix their milk with that of the ordinary cows. The buffalo cow is not a heavy milker, but, like the native Indian cow, she produces a high ratio of butter-fat, the majority indeed giving up to $7\frac{1}{2}$ per cent. A mixture accordingly of two parts cow's milk and one part buffalo's milk usually gives about the desired percentage in the mixed milk. But of course that did not get over the question of increasing the yield of the native cows, and to do this experiments were carried out with Ayrshires, Holsteins, Shorthorns, and one or two other milky breeds. It was interesting to hear from Mr. Smith that of all these the Ayrshire did best. Not only did the imported animals themselves live better than did those of either of the breeds mentioned, but their progeny were generally of a hardier class, while they came consistently more milky. So pleased are the authorities with Ayrshires for this purpose, that they have practically adopted the Ayrshire bull as their crossing animal, some having been imported this year for this purpose alone. We have seen recent photographs of first crosses between Ayrshire bulls and native cows taken on the Government farms in India, and while the animals preserved undoubted indications of their mixed ancestry in slightly dropping ears, and in rather dreamy heads in many cases, they also showed distinct traces of the Ayrshire in their colourings and body formation. Many of the animals are spotted and speckled just as is often seen in a mixed-colour Ayrshire at home, while the drooping quarters of the native cow is nearly always minimized, if it is not entirely eliminated. Mr. Smith is greatly pleased with the result of the cross, and says that already, through its use, it has been possible to increase the average herd yield as compared with the wholly native cow days by something approaching 100 per cent. An interesting feature of the Ayrshire crosses is that there is almost

no trace of the hump of the native cow on them. The excrescence seems to disappear at once, while the crosses are very little short of the native cattle in hardiness and ability to stand the often trying heat. Very fair crosses were got from both the Shorthorn and the Holstein in some cases, but the former especially were inclined to go to beef, and the latter were greatly affected by the climate, many of the original importations dying before full use could be got of them."

In this connection the following facts taken from an article on "An Indian Dairy Farm (New Style)" at Bangalore by Rev. Harold Short published in the same issue of the *Journal of Dairying and Dairy Farming in India* will be read with special interest.

"We inspected some of the Ayrshire bulls, which are imported from Scotland yearly—13 arriving last year—also a few from Australia.

"They have worked a wonderful improvement in the Indian cattle. Crossed with the "Hansi" cow from Delhi, the "Saniwal" from the Punjab or the "Sindi" from Sind district there is an upward result in appearance and milk production.

"The highest price for a country cow is £10 to £20. A half-bred Ayrshire goes for £25 to £40.

"On the first cross the unsightly hump on the shoulders of the native cow and the loose hanging flesh from the neck disappear, the horns are shortened and the whole formation of the animal is broadened and deepened. This improvement has been increased to the third generation. We saw an heifer of 18 months—the oldest of the fourth generation. Its products are awaited with great interest. The crosses have calved at 2½ years, but the country cow knows not the joy of maternity until her fourth year. But the greater value of the cross is shown of course in the milk supply.

"The following 'Comparison Statements' will show the extent of the increase.

"The Saniwal-Ayrshire 'Jill' has shown the common continued increase with each lactation period—her first giving 7,997 lb., the second 8,031, while the third is proceeding as shown below. The calf is always taken away or weaned after seven days.

Comparison Statement of Yields-fat.

6 of the best half-breds.

No. of Cow.	Yields. lb.	Fat. lb.
133	9,450	418·50
131	7,409	287·48
138	6,183	248·00
141	5,217	245·19
132	5,377	247·34
127	4,495	184·50
Total	38,131	1,631·01
Average	6,355·17	271·83

6 of the best country-breds.

No. of Cow.	Yields. lb.	Fat. lb.
18	4,009	200·11
28	3,858	180·95
30	3,710	188·70
22	3,606	176·40
31	3,400	170·00
36	3,154	158·00
Total	21,737	1,074·16
Average	3,622·83	179·02

6 of the poorest half-breds.

No. of Cow.	Yields. lb.	Fat. lb.
290	3,694	166·50
140	3,628	145·05
288	3,616	144·66
135	3,383	137·70
261	3,349	130·69
242	2,994	120 00
Total	20,664	844·60
Average	3,444	140·76

6 of the poorest country-breds.

No. of Cow.	Yields. lb.	Fat. lb.
15	1,529	76·45
7	1,306	62·68
24	1,233	60·41
16	1,167	58·35
21	1,127	52·89
9	1,047	47 27
Total	7,409	358·05
Average	1,234·83	59·67 "

At Pusa also Ayrshire bulls have been imported for crossing with the poorest milkers of the Montgomery herd. The experiments are still in progress but so far as they have gone they promise success.—[Editor.]

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Albuminoid Ratio. The albuminoid ratio was first "made" in Germany, and like a good many other German things it was found to be unsuitable for us. The writer long ago pointed out that as these rations were worked out on German animals, with German food, under a German climate, they would require to be greatly modified* to suit us, and he is rather pleased to find that many

* Kellner's famous stock work on the subject "The Scientific Feeding of Animals" was always held by the best British agriculturists to be totally inaccurate regarding its treatment of roots in rations. The truth is, the German never has and never will rightly understand what we mean by 'roots' as he can only deal in sugar-beet and vegetables which hardly rank as cattle food.—[W. S.]

other people have come round to this way of thinking. The first change was made by the Americans, who found that the German figures were quite wrong for America, and drew up a scale for themselves. The reaction has come to us now, and saner ideas are prevailing. To put the matter generally, it is found that a mixture of foods which shows a ratio of one to ten or one to twelve is quite as good as a more concentrated one, but with great many advantages in favour of the lower grade feeding. Thus, instead of using highly nitrogenous foods, like cotton-cake or bean meal, we can use those of a more starchy nature, and thus middlings, maize, rice, and feeds of that class are quite as efficient, while usually costing less in the market. As a matter of fact there is a rough correspondence between the market prices and richness in nitrogen in foods as there is in manures; cakes are nitrogenous, while such things as maize, rice, middlings, etc., are not. All this in practice means that we shall get as good result on a less forcing ratio than we have hitherto used, with a corresponding improvement in the health of the animals. We shall have less milk fever among cows, for instance, on a more starchy food than on one rich in albuminoids. We have taken a long time to find these things out, and probably much harm has been done in past years by following a scheme of using foods in too concentrated a fashion; but it is not too late to alter and improve matters, and to use more of the "weaker" and cheaper foods and less of the "stronger" and dearer ones.—[PRIMROSE MCCONNELL. *Journal of Dairying and Dairy Farming in India, Vol. II, Part III.*]

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IN the *Mysore Economic Journal* for May, 1916, there is an interesting note on **Industrial Co-operative Societies** by Mr. Alfred Chatterton. While it is true that in the new development of the material resources of India the industrial co-operative society may possibly play a very important part it must be noted that before this can come about a very large amount of experimental work will have to be done. Hitherto, so far as is known, industrial co-operative societies have not met with any large measure of success, and the work they have undertaken is more of a commercial than

industrial character. Before starting an industrial co-operative society it is necessary that the ground should be prepared by preliminary training, and when machinery is to be set up efforts should be made to enlist the co-operation of surrounding villages so that there may be no shortage of raw material. In view of the amount of training and supervision which these societies require it is not advisable to attempt to increase their number at all rapidly. This will be clear from the description of the two Industrial Co-operative Societies established in the villages of Bannoor and Sabbenahalli in Mysore. These have worked sufficiently long to afford some indication of the difficulties which will have to be overcome before they are completely successful.

The Bannoor Co-operative Society possesses a rice mill and a sugarcane-crushing plant capable of turning out jaggery. The capital of the Society is Rs. 22,500 divided into 150 shares of Rs. 150 each (all of which have been subscribed and on each share Rs. 10 have been paid up). The Mysore Government have advanced the Society a sum of Rs. 20,000 with which to purchase machinery, and the plant has been erected by the Department of Industries. Mr. Chatterton reports that just before the sugar mill was completed the ryots in Bannoor managed to get all their cane milled on the old lines as they were disturbed by rumours regarding the probable success of the new plant. Only 30 maunds of jaggery was made here, but this small quantity has sufficed to dissipate their fears regarding the quality and quantity of the *gur* that can be turned out by the plant. The rice mill with a nominal capacity of 7 cwt. of clean rice per hour has up to date worked for 528¼ hours and has turned out 1,672 *khandies* of clean rice, the milling revenue being Rs. 1,457-11-6. As there was not enough paddy forthcoming the mill was not worked continuously, and even on working days was not worked full time. The people store paddy in their godowns and sell it at favourable times. They believe that paddy when stored keeps much better than rice and so they are unwilling to have it milled. This state of things is, however, changing. The mill is being worked by the Department and the members of the Co-operative Society hardly realize that it is their own property and

that if it is not a success they will have to make good the loss. This will, however, bring them to a realization of the importance of its working full time.

At Sabbenahalli the Co-operative Society has established a cane-crushing plant consisting of a 14 b. h. p. suction gas engine and a 12″ by 18″ roller mill with sufficient evaporating pans of the new type to turn out 250 maunds of jaggery a day. It worked throughout the whole of the last cane-crushing season and successfully dealt with the whole crop in the village. But as the crop in the village was a poor one there was not enough work for the cane-crushing plant. A larger area has been put down under the crop, and if the current season proves favourable it should do extremely well. Here again the members do not realize the nature of the undertaking upon which they have entered. While they appreciate the advantages the question of repayment of the loan does not seriously trouble them.

We quote the following remarks of Mr. Chatterton :—

"At Bannoor, the people are now beginning to appreciate the advantages of having a rice mill in their midst, and at Sabbenahalli, from the outset they made full use of the cane-crushing plant; but the whole work has so far been done by the departmental agency, and it seems likely that it will be some years before the Co-operative Societies will be able to take over the plants and work them themselves. Our object at the present time is to foster a sense of ownership with its responsibility and to associate and train the local people to manage the undertaking. Ultimate success seems assured, but the goal is a long way off, and it is not easy to devise methods by which departmental control and responsibility may be gradually relinquished."—[EDITOR.]

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The Goat as a Source of Milk.—In the *Journal of the Board of Agriculture,* London, Vol. XXII, No. 7, there is a very practical and useful note on this subject.

In view of the small initial expenditure entailed in the purchase of a goat, minimum housing accommodation required and the limited amount of cost of food and other maintenance charges and, above

all, the extraordinary hardiness and adaptability of this animal, goats can be profitably kept to supply milk for domestic use and it is for domestic rather than business purposes that the goat is here recommended. There is a widespread belief that goats' milk always possesses a peculiar flavour. This flavour may possibly be caused by the goat feeding on certain herbs, but it is far more probably due to a want of cleanliness of the utensils employed. The rich creamy taste of the goat's milk renders it more attractive to the palate than cow's milk. It is easily digested by children and especially infants. It is also far less likely to contain tubercle bacilli of animal origin.

In selecting a goat the purchaser should look to the following points :—

"The body should be long and fairly deep, although if the latter point is very marked, it is probable that the animal is aged. It is important that the ribs should be well sprung, whilst a long head and a slender neck are generally considered to indicate a good milking strain. If the goat is dry the quality of the udder cannot be ascertained, but if in milk the udder should be carefully examined. It should not only be of good size, but soft and pliable, and the teats should be long and pointed, as they are then most easily handled. It is always desirable for the purchaser to see the goat he is about to buy milked at least once before coming to a decision. This is necessary not merely to ascertain the actual yield, but to find out if the animal stands quietly while being milked. A goat purchased in milk should not be less than two years old or over five. The age can be detected by examining the teeth."

It is stated that in England there are at present five breeds of goats, two of which belong to what may be called the common kind and three to the improved varieties. The common type are English and Irish goats, the superior breeds being the Toggenburg of Swiss origin (the only strictly pure breed in Britain) and the Anglo-Nubian and the crosses "Swiss" and "Anglo-Swiss." The last cross is considered to be probably the best all-round goat in Britain.

Goats breed when very young, often have two, sometimes three, kids at one birth and often produce young twice a year. The period of gestation is about 21 weeks or roughly five months. If a family keeps three goats they may justly look for a regular supply of milk all the year round. Signs of the coming into season are in some cases very transient. They consist in frequent bleating, a constant shaking of the tail, a turgid condition of the vulva, loss of appetite and restlessness and a temporary diminution in the milk-yield if the goat is in milk. This condition will last from one to three days.

If the improvement of the stock for milk production is the object in view, it is essential to secure the services of a male bred from a good milker or still better having "milking blood" on both sides of his parentage. The kids will then be worth rearing. Otherwise it is better to destroy male kids and use all the milk from the goat for domestic purposes. It seldom pays to rear male kids. A well-bred male kid may however be retained if it is not possible to secure near at hand one for service whenever required. The repulsive odour and objectionable habits of he-goats are well known.

In the feeding of goats absolute cleanliness of food and of the receptacle to hold it is required. The use of a metal pail is therefore advocated. Another essential is variety of food as the goat will give up eating if a change is not provided. Economy in feeding should certainly be looked to. From their kid stage goats should be encouraged to eat all vegetable waste from the kitchen or house-hold scraps. Except poisonous shrubs there is hardly any plant which is not acceptable to the goat. Goats are active and industrious feeders.

For the first three or four days after kidding the milk should be fed to the kid as it is not then suitable for human consumption. After that time the goat can be milked twice or thrice daily. Milking should be carried out at regular intervals and the udder completely emptied each time. The more quickly the milking is done the better; otherwise, the goat will become impatient and restless. The last drops or 'strippings' are always the richest. In England an average goat will give at its flush three pints a day:

The total milk-yield in the case of an average goat is about 67 gallons a year, while in the case of better milkers it may go up to 80 to 90 gallons.

In India goats are successfully bred by professional shepherds in districts with moderate or light rainfall and light naturally well-drained soils. A considerable variety of natural herbage in the tract and clean ground to graze each day are essential for raising large flocks of goats and sheep. In small numbers goats are reared in this country and their value as milk-producers appreciated, but there is room for improvement, and goat-keeping for domestic purposes might be extended with great advantage in many districts where it is hardly known.—[EDITOR.]

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IN view of the scantiness of information available as to the relative values of various concentrated foods for dairy cattle in India, the work carried out at Lyallpur, under the direction of Mr. Roberts, Professor of Agriculture in connection with the **feeding of cotton cake** (undecorticated) **to dairy cattle,** and published in the *Journal of Dairying and Dairy Farming in India*, Vol. II, Part III, is of considerable interest. Gram is the usual concentrated food used in the Punjab. Cotton seed is chiefly used in that province for feeding buffaloes and milch animals and also to some extent working animals. For the past few years cotton seed cake has been manufactured in Lahore; its selling price is about Rs. 1-8 per maund f. o. r. Lahore. Eight cows were selected, and divided into two groups of four each. The two groups were nearly alike in total daily milk-yield and in length of lactation period. One group was fed with cotton cake, the other with gram. The cotton cake supplied was always first broken and then moistened for three hours before feeding. Small quantities of the cake were given to start with and this was mixed with gram. The proportion of cake was increased daily and that of gram decreased, until at the end of eight or nine days the gram was entirely replaced. A little trouble was experienced with one cow who refused to eat the cake at first unless mixed with gram. Gradually this was overcome, and later she consumed the cake greedily. At the end of the

second month the total increase in live weight in both the groups was found to be practically equal.

As regards quantity and quality of the milk the advantage after some time was found to be on the side of cotton cake rather than on gram.

It was found that 23 seers of cotton cake had the same nutritive value as 16 seers of gram. The feeding of cotton cake is very economical. Cotton cake costs Rs. 1-11 per maund in Lyallpur while gram runs at about Rs. 3-8 per maund. This will mean considerable saving to a dairyman keeping a herd of say 20 cows.

It appears therefore that cotton cake can be safely and economically fed to dairy cows in milk. It is possible that this food may not be suitable for cows nearing calving time, but further experience on this point is necessary.—[EDITOR.]

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WE print the following extract from a leaflet on "**Some Uses of Prickly-pear**" published by the Department of Agriculture, Madras.

"In parts of Coimbatore district, prickly-pear is used after decomposition and composting as a manure for dry land crops such as *cumbu*, *cholam*, dry *ragi* and garden crops like *ragi*, chillies, tobacco, wheat, plantains, sugar-cane, etc. This is, however, not resorted to by all. In many cases it is prickly-pear growing in corners of their fields or extending from outside into the fields that is cleared and composted by way of disposal. A few ryots compost prickly-pear especially when it is abundantly available near at hand; but this is not followed as much as it might be.

"Ryots, however, have taken up to the practice of carting to their fields the earth which accumulates under prickly-pear bushes for improving their lands. In tank bunds and 'porambokes,' nothing is paid for the earth itself, and the cost is only two annas per cart-load (when the distance to be carted is about half a mile), for clearing the prickly-pear to get at the earth beneath, digging the earth, loading and carting it to the fields. The price per cart is becoming higher gradually owing to the increased wages. The soil under the prickly-pear bushes is of high manurial value as it is very largely composed

of leaf mould and other organic matter blown in by the agency of wind. Prickly-pear itself contains more than 60 per cent. of organic matter (Dr. Leather's analysis) and if such a substance is composted with the rich soil found under these bushes the manurial value will certainly be enhanced. Many of our soils are deficient in organic matter and if a compost of prickly-pear and the soil found under it is made and applied, the result will be beneficial. By composting prickly-pear, ryots not only obtain manure but get rid of this pest which is at present a nuisance in many respects.

"The following methods may be adopted for composting :—

(1) A trench 3′ to 4′ deep and 6′ broad of any required length may be dug and kept ready during the interval between the first and second monsoons. During rainy days when the ryots have not got busy work, prickly-pear may be cut, removed, and filled in the trench and covered with soil that has been removed in digging it. The top of the trench will sink after some days owing to the decay of the stuff and at this stage the soil from under the removed bushes may be dug and thrown on the top. In places having good rainfall, this will make a good compost within one year. If the thorns have not decomposed thoroughly, this may be left for another year when the thorns also will decompose.

(2) In regions of scanty rainfall, prickly-pear may be removed and heaped up in convenient mounds and allowed to dry up during seasons when ryots have enough leisure at their disposal. Dried bushes, grasses, and other rubbish procurable in the vicinity may be spread over the heaps and set fire to. The thorny substance is partially burnt. At this stage the earth removed from under the bushes or from lands close by should be spread all over the heap which can then be left for some years until decomposition is complete. In three or four years, this will be fit for being carted to fields.

(3) If space is not available for the above, circular constructions similar to those used for grinding *chunam* should be made. The prickly-pear is then thrown into this pit and ground by a stone-grinder just as *chunam* is ground. Owing to the large amount of water in the stems the plant, when the stuff is ground, is converted into a jelly-like substance within half an hour and the whole mass

can be removed by *mammuties* and carried to places where compost is to be made. If this is filled in pits or covered with some earth, decomposition will easily set in. The thorns also will not stand erect but will lie flat and the nuisance they cause will be much reduced. In this case the manure will be ready within six to eight months.

"Prickly-pear can also be used to serve other useful purposes than the one above referred to. The water obtained after boiling prickly-pear for some time can be used as a drier in whitewashes. An ordinary pot or *chatti* is filled with prickly-pear cut into small pieces; as much water as the pot will hold is then added. The whole is boiled for about three hours and stirred during the process. When cool, the liquid is strained and added to separately prepared white or colour wash in the proportion of 1 to 150 or 160. Whitewash or colour wash treated in this way becomes fast and does not rub off easily. In Indian houses this fast colour is a great advantage as it does not soil the clothing or body when the newly whitewashed walls are touched."

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THERE has been a revival on the Bombay side of the question of utilizing prickly-pear as fodder for cattle. There is nothing in the discussion that has not been dealt with many times in these columns. In Australia where it has been tried for cattle feeding they seem to be coming to the conclusion that the best thing to be done with this pest is to destroy it utterly, and then if it can be used to any advantage well and good, if not it is a good riddance of bad rubbish. A process has been discovered there of **treating prickly-pear with arsenious trichloride,** by which extensive areas have been completely cleared. In the course of the operations it has been discovered that a big percentage of potash can be obtained from the ash of the prickly-pear, and preparations are being made to enable Australia to supplant Germany in the supply of potash.—(*Madras Mail.*)

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THE Fourth Annual Meeting of the **Indian Science Congress** will be held at Bangalore on the 10th, 11th, 12th, and 13th January

1917. H. H. the Maharaja of Mysore has consented to be Patron of the meeting whilst Sir Alfred Bourne, K.C.I.E., F.R.S., will be the President. The following Sectional Presidents have been appointed :—Mr. J. MacKenna, I.C.S. (Pusa), Agriculture and Applied Chemistry; the Rev. D. Mackichan (Bombay), Physics; Dr. Ziauddin Ahmad, C.I.E. (Aligarh), Mathematics; Mr. K. Ramunni Menon (Madras), Zoology; Mr. C. S. Middlemiss, C.I.E. (Calcutta), Geology; Dr. J. L. Simonsen (Madras), Chemistry.

REVIEWS.

Indian Journal of Economics, Vol. I, Part I, January 1916.—Issued quarterly by the University of Allahabad, Department of Economics. Subscription, Rs. 12 per annum. Single copy, Rs. 4.

We extend a welcome, belated but none-the-less sincere, to the excellent Journal which issues under the editorship of Prof. H. Stanley Jevons. The name is one which will recall many memories of early struggles with formal philosophical conundrums.

In his editorial foreword Prof. Jevons states that the issue of the Journal has been undertaken with a three-fold purpose—(1) to provide a medium for the publication of articles on Indian Economics by authors of standing ; (2) to furnish a convenient and compact vehicle of publication for original investigations made by the staff of the Economics Department of the Allahabad University ; and (3) to disseminate information about the economic activities of other countries.

The first issue is delightfully Indian in its subjects. It opens with an article on " Agricultural Banks in India " by that enthusiast Mr. D. E. Wacha ; and although we must record our emphatic dissent from his opinions we cannot but admit the force and vigour with which Mr. Wacha states his case. Personally we would rather pin our faith to what Mr. Wacha is pleased to call " these new-fangled societies, "—*i.e.*, Co-operative Societies—than to an institution like the Agricultural Bank of Egypt ; and we are firmly convinced that not only the financial but also the moral regeneration of India lies in the development of these co-operative societies. Easy money means easy debt. It is quite simple to liquidate a man's debts : it is a slower process to educate him and develop his character so that he will not fall into debt again. But of course

there are two sides to this as to all other questions; and Mr. Wacha certainly puts his case well.

A short paper on the Indian cotton trade by Prof. Todd is f llowed by a most stimulating paper by our old friend Mr. W. H. Moreland on the Ain-i-Akbari—a possible base line for the economic history of modern India. The figures relate to the latter part of the sixteenth century and the writer considers that if the figures the Ain-i-Akbari contains can be used they will furnish a real starting point for the modern economic history of the country. We hope that this article will act as a stimulus to some of our Indian students of economics to examine critically the available statistics of India before the British Government began to tabulate them. They would command great interest.

The other articles in this issue are an interesting comparison of the Southern States of America with India as regards economic conditions by Prof. Sam Higginbottom; a paper on Indian factory legislation by Mr. S. H. Fremantle, I.C.S.; and one on the teaching of economics by the editor. A set of able reviews of books on economic and kindred subjects completes the issue.

We congratulate the editor on the form and quality of his first number and we look forward with much interest to future issues. The awakening of an interest in economics, especially the economics of agriculture, is a most healthy sign of progress and we trust that under the stimulus of Prof. Jevons and his staff the circle of Indian workers in this most fascinating subject will be widely extended. —[J. M.]

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Bengal Economic Journal.—Edited by Prof. C. J. HAMILTON and Prof. J. C. COYAJEE. Published by Macmillan & Co., Ltd., Calcutta, Bombay, Madras, and London. Subscription Rs. 10 per annum.

WE have received the first number of the *Bengal Economic Journal* edited by Professors Hamilton and Coyajee, and we take this opportunity of welcoming a Journal which supplies a long felt want.

Economics are all too neglected in India. A little closer study of them in the past would have saved much money, notably in banking circles.

We would especially note the article on "The Moratorium" by Prof. Coyajee, and criticism of the "Report on Co-operation in India" by B. Abdy Collins. There is a cold, calm, hard common sense about them both which is most comforting in these days of lightning finance of the mushroom order. In the article on the Moratorium we would draw special attention to the statement made that "Both France and Germany have been preparing for decades against the present crisis; and yet when the time for action came, the former took refuge under the most comprehensive scheme of moratoria ever devised while the latter adopted a policy of the most lavish extension of loans, and, even then, could not avoid a certain number of moratoria. At least since the Agadir incident the German banks, by Imperial command, have striven to make their resources more liquid and concentrated at home. In France, too, constant preparations have been made both by the Bank of France and by the other great banks for a rapid financial mobilization. A high authority, H. Germain, could say on behalf of the other banks that they were ready for *any* event, if the Bank of France was ready. The present war dissipated all this confidence in a moment." The constant preparations made were of no avail; for the closing of the stock exchange rendered the most liquid securities of all banks unrealizable.

Such a fact should give those connected with finance furiously to think and we hope equally furiously to overhaul their financial machinery and see whether it would be capable of working under such a strain in a land where it is difficult to keep down rumours and to inspire confidence even far away from the actual crisis, and it must not be forgotten that as we increase facility of communication and exchange throughout the world we render the financial failure of one country likely to be felt more and more widely by all others. The days of splendid isolation are gone for ever.

Mr. Collins' remarks on auditors hit a weak spot and their truth is driven home by his reference to Indian banking circles.

In order that co-operative societies may be able to command the confidence of investors it is very necessary that the system of audit and the persons by whom this audit is conducted should be above suspicion. While there is no objection in principle to societies being audited by non-Government auditors licensed by the Registrar—in fact non-official audit is to be preferred as it is less likely to develop into a routine—it must be understood that the audit staff should not depend for their pay and prospects directly upon Central Banks and Unions. It is on these and other grounds that an Audit Federation somewhat on the lines of the Provincial Audit Union of the Central Provinces has much to commend it.

What is wanted in the auditor is local knowledge and sympathy backed by no personal interest in the matter. It has often been said that the manager of the local branch bank in an English agricultural town is the finest agricultural accounts auditor existing. He knows when to be stern and strict and when not to allow undue strictness to interfere with necessary progress because his knowledge enables him to value assets correctly and the valuing of agricultural assets requires a special knowledge which cannot be found in any outsider.

The progress of co-operative societies will render it necessary to train auditors in this line, if they are not to be hindered in their progress, not so much to audit accounts—many can do that—but to put the true value on the assets." His article is of the greatest interest and we hope he will write again. There is still plenty in the report awaiting criticism.—[W. S.]

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A Manual of Elementary Botany for India.—By Rai Bahadur K. RANGA ACHARI, M.A., L.T., Madras. Printed and published by the Superintendent, Government Press, Madras. Price Rs. 2.

UNTIL quite recently the professor or teacher of elementary botany in India was dependent on text-books written in Europe or America. Such books, while excellent in dealing with principles, are ill adapted for use in India, since the plants and conditions described in them are in many cases not found here. There exists a very considerable technical literature regarding Indian botany,

but the digest of that material suitable for a text-book has been made in only a few cases. The work under review is the most recent of these attempts to utilize local material for the elucidation of botanical principles and it certainly is the best work of its kind so far produced. The book has been printed and published by the Government Press, Madras, and the letterpress, plates, and general get-up are excellent. Considering this, the price is amazingly low—a most desirable thing, for Indian students will not, as a rule, indulge in expensive books.

The manual is avowedly elementary, and the writer confines his attention to the flowering plants. The morphology of many local examples is fully explained. The most striking parts of the book are those dealing with the anatomy of plants, illustrated by really convincing original microphotographs. Apart from the value to the student of the morphological and anatomical portions, they are also of value to the teacher in showing him what material to use for the demonstration of special points, and it is hoped that the very excellence of the book on its descriptive side will deter no student or teacher from going direct to the living plant.

As the book does not pretend to be a manual of laboratory practice, detailed directions are not given regarding microscopical technique and the designing of physiological experiments. At the same time it is desirable to develop the physiological section of the book, making it more precise, and dealing at greater length with the evidence on which the necessarily dogmatic text-book statements are based, *e. g.*, in the case of the study of plant nutrition by water cultures (p. 133), and in the case of the statement (p. 185) "it is obvious, that for the production of offsprings, the fusion of the male and female cells is essential even in the case of plants."

In reading through the book the scientific purist may take exception to many minor points, such as the mixing of classification systems by dividing plants into spermaphyta and cryptogams (p. 1), the calling of the web of a girder its flange (p. 91), and the statement that "groups of plants that give a distinctive feature to a locality are called 'formations'" (p. 330); but these detract little from its

value as a text-book. A complete and exhaustive index is however a necessity.

One problem confronting the author of such a book is to produce a work which shall be useful in all parts of this great continent. How far this problem has been solved can only be determined by trial, and we strongly recommend all professors and teachers of elementary botany to make use of the book and communicate their views to the author of the book.

It is to be hoped that in time text-books for India will be produced dealing with more advanced botany and especially with the cryptogams. Is it too much to hope that a group of professors and teachers may collaborate to produce a composite advanced manual for India on the lines of Strasburger's *Text-book of Botany*?

Manuals of applied botany are also required giving summaries of the great mass of valuable Indian work done in plant breeding, mycology, and economic botany generally.—(W. B.)

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The Year-book of the United States Department of Agriculture, 1915.—(Pages 616, Plates 75, Figs. 13, etc. Washington, Government Printing Office.)

THIS publication is perhaps one of the mirrors in which the economic progress of the world is most comprehensively reflected.

There are two outstanding features in the 1915 issue. One is, of course, the effect of the European war—reflected in the changes in acreage, value, and quantities exported, of crops; the other is the large number of articles which deal with voluntary organization among agriculturists.

With a record yield of wheat in 1914 and an increase of over 25 per cent. in the price, 37 per cent. of the crop grown in the States was exported; and the 1915 crop, estimated at over a thousand million bushels, again beat all records. On the other hand, a cotton crop 14 per cent. greater than that of 1913 was worth one-third less to American farmers, and a decrease of 15 per cent. in the acreage for 1915 coincided with a falling off of 20 per cent. in the yield per acre.

The prospect of a rise in the prices of American exports as compared with those of imports, as a result of the transfer of capital from Europe during the war, should be encouraging to the growers of long-stapled cotton in India.

Seven of the 24 articles in the Year-book relate to co-operative organization of one kind or another, and give a very comprehensive idea of the importance of this movement and the extent to which it can be fostered even in such a home of individualism as the United States.

The movement embraces almost every conceivable aspect of rural economy, from the breeding of livestock and the marketing of crops to dairying and the improvement of roads; and includes such diverse organizations as boys' and girls' clubs for specific purposes, local 'small community' clubs, and mutual insurance companies. In an article on "How the Department of Agriculture promotes Organization in Rural Life," Mr. C. W. Thompson, Specialist in Rural Organization, says:—

"Reviewing all the various types of organization through which the Department of Agriculture seeks to promote the welfare of the farmer, it may be noted that in every case the organization is undertaken for some specific purpose, and that that purpose is one which can better be accomplished through concerted effort than through individual action alone. This represents the general policy of the Department with regard to organization among farmers. The Department does not encourage organization simply for the sake of organization, nor does it encourage the indiscriminate formation of organizations for any and every object whatsoever; for some objects may be accomplished efficiently and economically by individuals working each by himself.

"For the accomplishment of those objects which clearly call for co-operative or co-ordinated action on the part of the farmers, the Department encourages a more efficient use of existing organizations, where that is practicable, either by inducing them to take up new lines of activity, or by pointing out efficient methods of carrying on the activities for which they were originally formed. Where new associations are needed, the Department endeavours to secure

organizations which are as simple in form as possible, and to keep in the foreground the object of the organization rather than the organization itself."

It is difficult to imagine a more effective way of counteracting the centralizing tendencies of Governments whether autocratic or socialistic, than by voluntary organization on these principles; and reading these articles one catches a glimpse of a future when the activities of Governments may be merged in the public recognition and inspection of voluntary associations, not merely organized for agriculture, commerce, or education, but co-ordinated for readily accessible justice, for police, and, on a basis wider and more solid than has ever hitherto been possible, for military defence of the common weal—the ultimate prerogative of centralized authority.—[A.C.D.]

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Note on Cattle of the Bombay Presidency.—Bulletin No. 75 of the Department of Agriculture, Bombay. Printed at the Yeravada Prison Press, Poona. Price As. 3½ or 4*d*.

THIS Bulletin deals with cattle of the Bombay Presidency excluding Sind. The author, Rao Sahib Kelkar, is a senior officer of the Department who is intimately acquainted with the local conditions of his province. The province is divided into nine tracts and in each the conditions are briefly noted on. In the chapters on Breeds of Cattle, Dairy Industry, and Feeding of Cattle, the author has included a large amount of original local information acquired by personal contact with the cattle-owners. Original information of this nature is always valuable, and unless such is put on record agricultural departments stand to lose much valuable material when members leave the service.

A plan is given for the treatment of 50 acres to yield green fodder continuously throughout the year. This problem would, of course, have to be separately worked out for each tract. It will prove a very fruitful source of work and one which will have to be seriously taken in hand in all parts of India.—[G. S. H.]

Dairying and Dairy Breeds (*In Marathi*).—BY B. K. GHARE, L. AG., Pages 11 + 195. Printed by Mahadeo Sakharam Dáte at the Vaidic Patrika Press. Price Re. 1.

THE author of this book, Mr. Bhaskar Kashinath Ghare, L. Ag., Agricultural Lecturer at the Cawnpore Agricultural College, brought out a small pamphlet in Marathi under the title of "Milk and Dairying" three years ago, and the book under review is a much enlarged edition of the same with certain additions and fuller treatment of the subjects dealt with therein. As far as we are aware this is the first book of its kind in Marathi treating so fully and simply about the importance of milk in all its aspects and the care of animals, etc., and is a welcome addition to the literature on technical subjects in that language. The author seems to have made every endeavour to avoid English scientific terms or their high-sounding coined equivalents of Sanskrit origin in his work, and this has tended to make the subject-matter easy of comprehension.

In the introduction written for this book by Mr. M. G. Phatak, L. Ag., the importance of pure milk and its production has been shown in a concise but impressive way, and it conveys to the mind of the reader a vivid idea of dairying and animal husbandry as it should be practised in India.

We find the whole book packed with very useful facts which have been well put together. But we also notice some statements which either require modification or amplification.

The process of secretion of milk as described in Chapter I is too brief to be easily followed and should be made clear enough.

The author, in his enthusiasm for extolling the virtues of milk, has gone the length of attributing to it the power of curing formidable diseases like consumption. We do not doubt the digestibility and nutritive value of pure milk diet in certain diseases, but we cannot agree with him in endowing it with curative powers over this of all the diseases.

In Chapter IV the slope recommended for gutters in the byre for the passage of urine and dung is 6 inches to every 20 feet of

length. This is unnecessarily steep and we believe that a slope of 3 inches to 25 feet of length ought to suffice for this purpose.

In describing circulation of blood the lungs are said to be a part of the circulatory system which is not the case. They belong to the respiratory apparatus.

Chapter VII regarding common ailments of cattle is very meagrely treated. In this chapter under the heading of "Hoven" it is recommended by way of treatment to force the animal to run about. This is a dangerous practice.

In Chapter VIII on cattle-breeding the description of breeds lacks precision, and the illustration used to represent the Jafferabadi buffalo is not a typical one. All the illustrations of cattle are rather indistinct.

There are many typographical mistakes both in figures and words throughout the book, and the author would do well to attend to these and the points referred to above when bringing out another edition of the book.

The book on the whole is very useful and informative and as such it will, we hope, be appreciated by the Marathi-reading public. —[J. H.]

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1ST FEBRUARY TO 31ST JULY, 1916.

No.	Title	Author	Where published
	GENERAL AGRICULTURE.		
1	The *Agricultural Journal of India*, Vol. XI, Part II. Price Rs. 2; annual subscription Rs. 6.	Issued from the Agricultural Research Institute, Pusa.	Messrs. Thacker, Spink & Co., Calcutta.
2	Special Indian Science Congress number of the *Agricultural Journal of India*. Price Rs. 2 or 3*s*.	Ditto ...	Ditto.
3	Report on the Progress of Agriculture in India for 1914-15. Price As. 5 or 6*d*.	Agricultural Adviser to the Government of India, Pusa.	Government Printing, India, Calcutta.
4	Proceedings of the Board of Agriculture in India, held at Pusa on the 7th February, 1916, and following days (with Appendices). Price Re. 1-2 or 1*s*. 9*d*.	Issued from the Agricultural Research Institute, Pusa.	Ditto.
5	Soil Aeration in Agriculture, Bulletin No. 61 of the Pusa Agricultural Research Institute. Price As. 4 or 5*d*.	A. Howard, C.I.E., M.A., Imperial Economic Botanist.	Ditto.
6	Annual Report of the Board of Scientific Advice for India for the year 1914-15. Price R. 1 or 1*s*. 6*d*.	Issued by the Board of Scientific Advice for India.	Ditto.
7	Agricultural Statistics of India for 1913-14, Vols. I and II. Price Rs. 2-8 and R. 1 respectively.	Issued by the Department of Statistics, India, Calcutta.	Ditto.
8	Estimates of area and yield of principal crops in India for 1914-15. Price As. 4.	Ditto ...	Ditto.
9	Season and Crop Report of Bengal for 1915-16. Price R. 1 or 1*s*. 6*d*.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depôt, Calcutta.
10	Groundnut.—Leaflet No. 1 of 1916, of the Bengal Department of Agriculture (for free distribution).	F. Smith, B.Sc., Deputy Director of Agriculture, Bengal.	Obtainable from the Departmen of Agriculture, Bengal.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		General Agriculture—contd.	
11	Agricultural Statistics of Bengal for 1914-15. Price As. 12 or 1s. 3*d*.	Issued by the Government of Bengal, Revenue Department.	Bengal Secretariat Book Depôt, Calcutta.
12	Season and Crop Report, Bihar and Orissa for 1915-16. Price As. 6 or 6*d*.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Bihar and Orissa, Patna.
13	Leaflet on the use of *Dhaincha* ...	Ditto ...	Ditto.
14	*Agricultural Journal* (published half yearly), Vol. III, Part II. Subscription R. 1 per annum.	Ditto ..	Ditto.
15	Agricultural Statistics of Bihar and Orissa for 1914-15.	Ditto ...	Ditto.
16	Report on the Benares Agricultural Station for the year ending 30th June, 1915. Price As. 6 or 6*d*.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
17	Report on the Government Horticultural Gardens, Lucknow, for the year ending 31st March, 1916. Price As. 4 or 6*d*.	Ditto ...	Ditto.
18	Report on the Government Botanical Gardens, Saharanpur, for the year ending 31st March, 1916. Price As. 4 or 6*d*.	Ditto ...	Ditto.
19	A note on the improvement of the indigenous methods of *Gur* and Sugar making in the United Provinces and a report on the Government Experimental Sugar Factory, Nawabganj, Bareilly District. Price As. 4 or 4*d*.	W. Hulme, Sugar Engineer Expert to the Government of India, and R. P. Sanghi, Sugar Chemist, Experimental Factory, Nawabganj.	Ditto.
20	Year Book of the Punjab Agricultural Department for 1916. Price Re. 1-4.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
21	Prospectus of the Punjab Agricultural College, Lyallpur (for free distribution).	Ditto ...	Ditto.
22	Expenses and Profits of cultivators in the Punjab (for free distribution).	Ditto ...	Ditto.
23	Cotton Survey Report of the Gujranwalla District (for free distribution).		Ditto.
24	Cotton Survey Report of the Jhang District (for free distribution).	Ditto ...	Ditto.
25	Lawrence Gardens' Report. Price Anna 1 or 1*d*.	Ditto ..	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
26	Annual Report of the Department of Agriculture, Bombay, for 1914-15. Price As. 12 or 1*s.* 2*d.*	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
27	Annual Report of the Sukkur Agricultural Station for 1914-15. Price As. 5 6 or 6*d.*	Ditto ...	Ditto.
28	Annual Report of the Surat Agricultural Station for 1914-15. Price Rs. 1-10 or 2*s.* 6*d.*	Ditto ...	Ditto.
29	Annual Report of the Dohad Agricultural Station for 1914-15. Price As. 10-9 or 1*s.*	Ditto ...	Ditto.
30	Annual Report of the Dhulia Agricultural Station for 1914-15. Price As. 10-6 or 1*s.*	Ditto ..	Ditto.
31	Annual Report of the Jalgaon Agricultural Station for 1914-15. Price As. 9-9 or 11*d.*	Ditto ...	Ditto.
32	Annual Report of the Nadiad Agricultural Station for 1914-15. Price As. 13 or 1*s.* 3*d.*	Ditto ...	Ditto.
33	Annual Report of the Gokak Canal Agricultural Station for 1914-15. Price As. 11-3 or 1*s.* 1*d.*	Ditto ...	Ditto.
34	Annual Report of the Gadag Agricultural Station for 1914-15. Price As. 9-9 or 11*d.*	Ditto ...	Ditto
35	Annual Report of the Dharwar Agricultural Station for 1914-15. Price As. 13-9 or 1*s.* 4*d.*	Ditto ..	Ditto.
36	Annual Report of the Alibag Agricultural Station for 1914-15. Price As. 10-6 or 1*s.*	Ditto ..	Ditto.
37	Annual Report of the Ratnagiri Agricultural Station for 1914-15. Price As. 9-6 or 11*d.*	Ditto ...	Ditto.
38	Annual Report of the Mirpurkhas Agricultural Station for 1914-15. Price As. 5-3 or 6*d.*	Ditto ...	Ditto.
39	Annual Report of the Landhi Agricultural Station for 1914-15. Price As. 4-6 or 5*d.*	Ditto ...	Ditto.
40	Annual Report of the Larkhana Agricultural Station for 1914-15. Price As. 4-6 or 5*d.*	Ditto ...	Ditto.
41	Annual Report of the Manjri Agricultural Station for 1914-15. Price As. 14 or 1*s.* 4*d.*	Ditto ...	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
42	Annual Report of the Experimental plots in Satara and Sholapur Districts for 1914-15. Price As. 1-6 or 2*d*.	Issued by the Department of Agriculture, Bombay.	Government Central P Bombay.
43	Annual Report of the Ganeshkhind Botanical Gardens for 1914-15. Price As. 4 or 5*d*.	Ditto ...	Ditto.
44	Annual Report of the Agricultural College Dairy, Kirkee, for 1914-15. Price As. 4 or 5*d*.	Ditto ..	Ditto.
45	Annual Report of the Poona Agricultural College Farm for 1914-15. Price Re. 1-1 or 1*s*. 7*d*.	Ditto ...	Ditto.
46	Annual Report on the Experimental work of the Economic Botanist and his staff for 1914-15. Price As. 2 or 3*d*.	Ditto ..	Ditto.
47	Report on the Committee appointed to consider measures for the improvement of the milk supply in large cities in the Bombay Presidency. Price As. 3 or 3*d*.	G. F. Keatinge, C.I.E., I.C.S., President of the Committee.	Ditto.
48	Note on Cattle of the Bombay Presidency. Bulletin No. 75 of 1915 of the Department of Agriculture, Bombay. Price As. 3-6 or 4*d*.	Rao Sahib G. K. Kelkar.	Ditto.
49	Artificial Manures—Experiments with their value for crops in Western India. Bulletin No. 76 of 1915 of the Department of Agriculture, Bombay. Price As. 4 or 5*d*.	Harold H. Mann, D.SC., and S. R. Paranjpe, B.SC.	Ditto.
50	Experience of Kalli Chitti Abhoye Naidu of Pulla, Kistna District, on Green Manure. Leaflet No. 1 of 1916 of the Department of Agriculture, Madras.	Chitti Abhoye Naidu ...	Government Press, Madras.
51	Some Uses of Prickly Pear. Leaflet No. 2 of 1916 of the Department of Agriculture, Madras.	J. Chelva Ranga Raju ...	Ditto.
52	Groundnut cultivation in the Upland Taluks of the Godavari District. Leaflet No. 3 of 1916 of the Department of Agriculture, Madras.	D. Balakrishna Murthi ..	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
53	Pulichai, Mailam, or Jari Cotton in Tinnevelly and Ramnad Districts. Leaflet No. 4 of 1916 of the Madras Department of Agriculture.	G. A. D. Stuart, I.C.S. ...	Government Press, Madras.
54	The *Agricultural and Co-operative Gazette* (Monthly) from February to July, 1916. Price As. 2 per issue.	Issued by the Department of Agriculture, Central Provinces and Berar.	Shalom Press, Nagpur.
55	A Handbook of Agricultural Leaflets (in Hindi). Price As. 3-6.	G. Evans, M.A., Deputy Director of Agriculture, Northern Circle, Jubbulpur.	George Printing Press, Jubbulpur.
56	Season and Crop Report of Burma for the year ending 30th June, 1916. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
57	Report of the Mandalay Agricultural Station (including Natywagon Sub-Station) for the year 1914-15. Price As. 6 or 7*d*.	Ditto ...	Ditto.
58	Report of the Padu Agricultural Station for the year 1914-15. Price As. 2 or 2*d*.	Ditto ...	Ditto.
59	Report of the Buggi Experimental Plot for the year 1914-15. Price As. 2 or 2*d*.	Ditto ...	Ditto.
60	Burma Agricultural Calendar for 1916-17 (in Burmese).	Ditto ...	Ditto.
61	Minutes of the 8th Half Yearly Conference of the Agricultural Department held at Maymyo on the 17th and 18th April, 1916.	Ditto ...	Ditto.
62	Sugarcane Cultivation—Cultivators' Leaflet No. 46 of the Department of Agriculture, Burma.	A. Mackerral, M.A., B.Sc., Deputy Director of Agriculture, Southern Circle, Burma.	Ditto.
63	Report on the Season and Crops of Assam for 1915-16. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
64	Summary of Remarks on the Kharif Crops of the North-West Frontier Province for 1915. Price As. 4 or 4*d*.	Issued by the Department of Agriculture, North-West Frontier Province.	... ..
65	The *Journal of the Madras Agricultural Students' Union* (Monthly). Annual Subscription, R. 1.	Madras Agricultural Students' Union.	Literary Sun Press, Coimbatore.
66	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
67	The *Journal of Dairying and Dairy Farming in India.* (Issued quarterly).	Published by the Indian Committee of the Dairy Education Association.	Messrs. Thacker, Spink & Co., Calcutta.
68	*Poona Agricultural College Magazine* (Quarterly). Annual Subscription, Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
69	Report on the Working of the Government Gardens and Parks in Mysore for 1914-15.	Issued by the Department of Agriculture, Mysore.	Government Press, Bangalore.
70	Report on the Operations of the Department of Agriculture and Fisheries, Travancore for 1914-15.	Issued by the Department of Agriculture, Travancore.	Government Press, Trivandrum.
	AGRICULTURAL CHEMISTRY.		
71	The Gases of Swamp Rice Soils, Part III. A Hydrogen-oxidizing Bacterium from these Soils. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IV, No. 4. Price As. 12 or 1*s.*	W. H. Harrison, M.SC., Government Agricultural Chemist, Madras, and P. A. Subramania Aiyer, B.A., Assistant to the Government Agricultural Chemist.	Messrs. Thacker, Spink & Co., Calcutta.
72	Some Factors affecting the cooking of Dholl (*Cajanus indicus*). Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IV, No. 5. Price R. 1 or 1*s.* 6*d.*	B. Viswanath, T. Lakshman Row, B.A., and P. A. Raghunathaswami Ayyangar, D.A., Assistants to the Government Agricultural Chemist, Madras.	Ditto.
73	Studies in the Chemistry and Physiology of the leaves of the Betel vine (*Piper betle*) and of the Commercial bleaching of betel-vine leaves. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IV, No. 7. Price R. 1 or 1*s.* 6*d.*	Harold H. Mann, D.SC., Agricultural Chemist to the Government of Bombay, and V. G. Patwardhan, B.Ag.	Ditto.
74	Note on the Soil of the Experimental Farms. Bulletin No. 13 of 1916 of the Department of Agriculture, Burma. Price As. 2 or 2*d.*	F. J. Warth, M.SC., Agricultural Chemist, Burma.	Government Printing, Burma, Rangoon.
75	A Soil Survey of the Guntur Delta. Bulletin No. 70 of the Department of Agriculture, Madras. Price Re. 1-8 or 2*s* 3*d.*	W. H. Harrison, M.SC., and B. Vishwanath.	Government Press, Madras.
	BOTANY.		
76	Some Varieties of Indian Gram (*Cicer arietinum*, L.). Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VII, No. 6. Price R. 1 or 1*s.* 6*d.*	Albert Howard, C.I.E., M.A.; Gabrielle L. C. Howard, M.A.; and Abdur Rahman Khan, Second Assistant to the Imperial Economic Botanist.	Messrs. Thacker, Spink & Co., Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Botany—contd.		
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